GEOLOGICAL SURVEY BRANCH
DEPARTMENT OF MINES AND ENERGY
GOVERNMENT OF NEWFOUNDLAND AND LABRADOR

REPORT OF ACTIVITIES

1989

St. John's, Newfoundland
1989

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Compiled by
C.P.G. Pereira and D.G. Walsh

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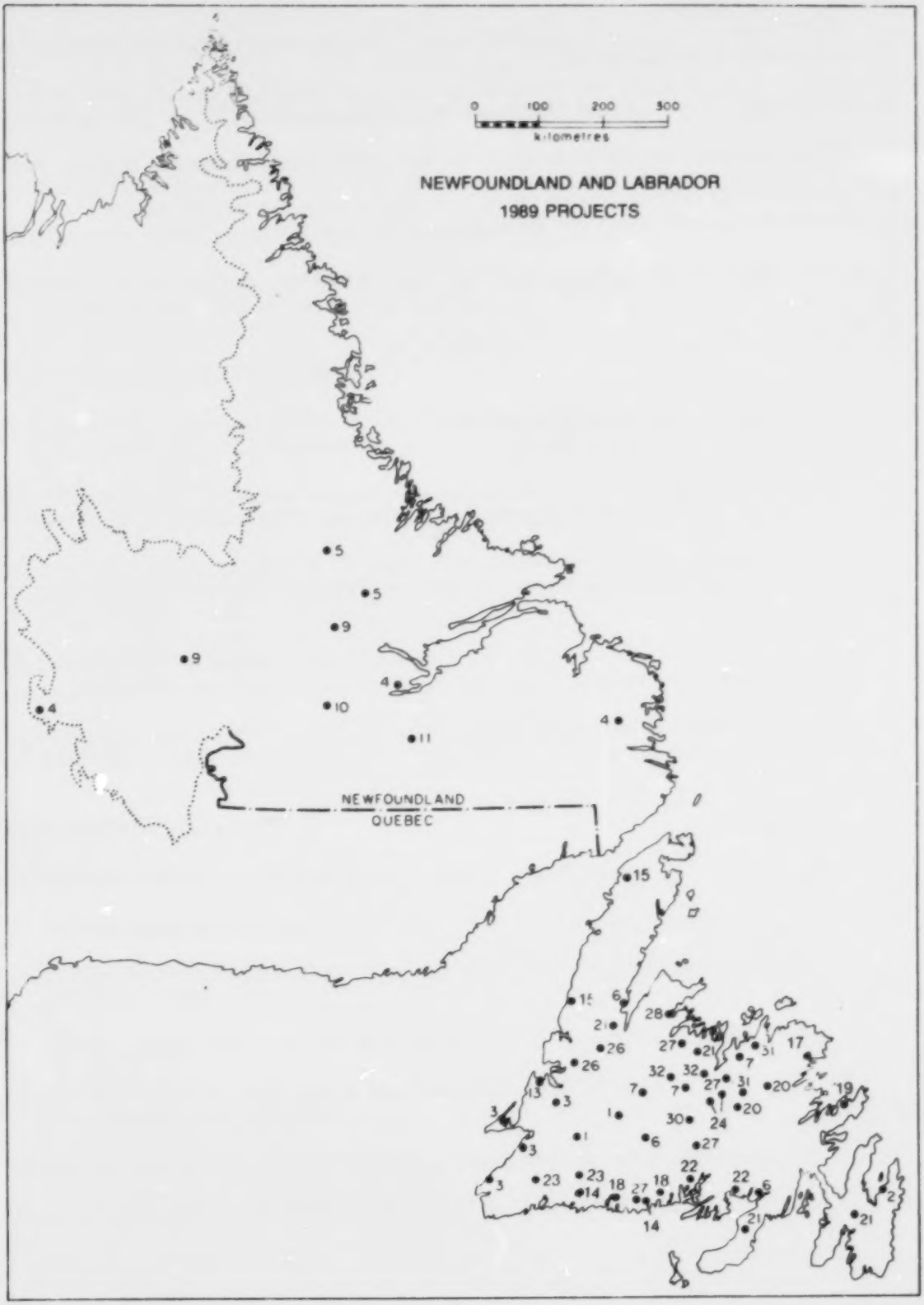
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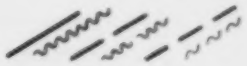
NEWFOUNDLAND AND LABRADOR
1989 PROJECTS
NEWFOUNDLAND
QUEBEC

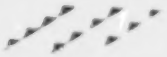
GEOLOGICAL MAP SYMBOLS

Geological contact (defined, approximate, assumed, gradational)

Fault (defined, approximate, assumed)



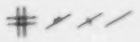
Thrust fault (defined, approximate, assumed)



Zone of numerous imbricate thrust faults

Bedding, tops known (horizontal, inclined, vertical, overturned)

Bedding, tops unknown (horizontal, inclined, vertical, dip unknown)



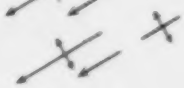
Pillow bedding, tops known (inclined, vertical)

Flow banding (inclined, vertical)

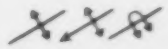
Fracture cleavage (inclined, vertical)

Syncline, showing direction of plunge (defined, approximate)

Anticline, showing direction of plunge (defined, approximate)



Antiform (horizontal, plunging, overturned)



Synform (horizontal, plunging, overturned)

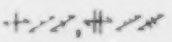
Minor fold axis (with plunge)

S folds, Z folds

Gneissic foliation (horizontal, inclined, vertical, dip unknown)

Schistosity, cleavage, foliation (horizontal, inclined, vertical)

S_1, S_2



Foliation due to thrusting (inclined, vertical)

Lineation, fold axis, mineral rodding

Jointing (horizontal, inclined, vertical)

Primary igneous layering (inclined)

Shear zone (approximate)

Alteration zone

Unconformity

Contact inferred from magnetic anomaly

Glacial striae

Drift covered area

Topographic lineaments from aerial photographs

Road

Power transmission line

Mine Pb

Mineral Occurrence x Zn

Location of measured section

Abbreviations

Arsenopyrite	asp	Iron formation	i-f
Asbestos	asb	Magnetite	mag
Chalcopyrite	cp	Molybdenite	mo
Copper staining	cs	Pyrite	py
Fluorite	fl	Pyrrhotite	po
Galena	gn	Radioactive minerals	ra
Hematite	hem	Serpentine	sup
		Sphalerite	sp

Chemical symbols are used for elements, e.g. Cu.....copper

ECONOMIC GEOLOGY

METALLOGENIC STUDIES, VICTORIA LAKE GROUP

D.T.W. Evans[1] and B.F. Kean[2]
[1]Mineral Deposits Section
[2]Mineral Economics Section - Mineral Resource Management Branch

Regional metallogenic studies of the Victoria Lake Group are nearing completion. The study is a comprehensive program that consists of the revision of the regional geology, deposit level studies, regional geochemical sampling of mafic volcanic rocks, sampling of alteration zones for gold mineralization, age dating (Greg Dunning; Earth Sciences, Memorial University of Newfoundland), and documentation of gold mineralization. Included in the program was a detailed study of the Midas Pond Prospect, which formed part of a M.Sc. study by one of us (DTWE), as well as a study of the regional linear structures and their relationship to gold mineralization. This program identified a number of significant features, which indicated a need for major revisions to the geology of the Victoria Lake Group and to the interpretation of the geology of the Dunnage Zone. Significant aspects of the program are outlined below.

1) A comprehensive revision of the geology of the Victoria Lake Group based on a new exposure (Kean and Evans, 1988).

2) Detailed geochemical studies of mafic volcanic rocks within the Victoria Lake Group suggest a wide variation in tectonic settings for these rocks; these rocks may prove useful as guides in massive sulphide exploration (Kean and Evans, 1988; Swinden *et al.*, 1989).

3) Age-dating of felsic volcanic rocks by Greg Dunning has identified at least three different ages of volcanic arc activity within the Victoria Lake Group (Dunning, 1986; Dunning *et al.*, 1987; Kean and Evans, 1988).

4) The detailed geochemical and age-dating studies suggest that the Victoria Lake Group is a composite volcanic arc terrane, comprising rocks of various ages and formed within different tectonic settings.

5) Detailed examination of regional structural linears, based on interpretation of gradiometer, colour infrared airphotos and C-SAR radar imagery, suggests a direct link between these linears to both the sites of gold mineralization (Evans and Kean, 1987; Kean and Evans, 1988) and to variations in age-dates and geochemistry of the volcanic sequences. A number of these structures may actually represent thrust faults, which probably complicates the geology of the group and may explain the variations in age and geochemistry.

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GOLD POTENTIAL OF THE EASTERN AVALON HIGH-ALUMINA BELT: AVALON METALLOGENY PROJECT, 1989

J.P. Hayes and C.F.O'Driscoll
Mineral Deposits Section

The eastern Avalon high-alumina belt is defined as a 14-km-long, north-south-trending zone of pyrophyllite, sericite ± pyrophyllite occurrences and related silicified and locally, pyritiferous rocks. It is developed within the Precambrian Harbour Main Group volcanic rocks along the eastern margin of the Holyrood intrusive suite.

This project was initiated, in 1989, to examine the relationship between the types of alteration developed here and essentially similar types of alteration developed elsewhere in the Avalon Zone, which are known to host gold mineralization. The Hickeys Pond belt on the Burin Peninsula (Huard and O'Driscoll, 1985, 1986; Huard, 1989) is one example of high-alumina mineralization associated with gold in the Newfoundland Avalon Zone. In North and South Carolina, gold is currently being mined adjacent to high-alumina zones, in rocks that are equivalent to those of the Avalon Zone. The alteration zones in the Carolinas are of similar size to those seen in the eastern Avalon high-alumina belt.

Previous studies have concentrated on regional geology (Dawson, 1963) and the geological setting and genesis of the pyrophyllite deposits (Vhay, 1936; Lee, 1958; Keats, 1970 and Papezik *et al.*, 1978). Exploration activity in the past has primarily been conducted by Newfoundland Minerals Limited for pyrophyllite. Recent efforts by APEX Geological Consultants (Saunders, 1986) and Esso Minerals (Lenters, 1986) have been directed towards gold.

The present project focused on the mapping and sampling of the alteration system, from the vicinity of the Oval Pit Mine to its apparent southern limit in the Thousand Acre Marsh. The distribution of the host rocks and the main pyrophyllite occurrences are shown in Figure 1.

The felsic volcanic horizon, which hosts the main alteration, occurs in a north-south-trending belt that is cut by the Holyrood intrusive suite. Locally, it contains down-faulted blocks of younger, clastic sedimentary rocks that are derived from the felsic and mafic volcanic rocks within the sequence. The sedimentary rocks exposed in the Oval Pit Mine contain clasts of the altered rocks, and cobbles of silicified felsic volcanic rocks are present in the basal Cambrian conglomerate exposed beneath the Manuels River Bridge. These establish a Precambrian age for the alteration.

Three principal zones can be defined, which are discrete but commonly overlap within the alteration system:

1) **Pyrophyllite Zone.** This zone is developed locally, along the belt and is coincident with intense shearing of the host rock. The rocks range from fine grained quartz-pyrophyllite sericite schist to massive pyrophyllite. Residual altered and relatively unaltered host rocks are found as enclaves ranging in size from millimetre- to decimetre-scale blocks within these zones. The most common rock type in these zones is a blocky pyrophyllite schist, with 1- to 10-cm-scale blocks of white pyrophyllitized, sericitized and partly silicified rhyolite in a pyrophyllite-rich matrix. This zone locally contains discontinuous 10- to 75-m-sized "mini" zones of relatively unaltered felsic volcanic rocks in which the primary volcanic textures such as ash-flow layering, flowbanding and 1- to 5-cm lithophysae are clearly preserved. The main pyrophyllite occurrences within the belt are found at the Oval Pit Mine, Mine Hill, Trout Pond, Dog Pond and Jakes Gully. Massive lenses of relatively pure pyrophyllite are locally host to diaspore nodules, which have been previously reported to contain rutile and minor barite (Papezik *et al.*, 1978).

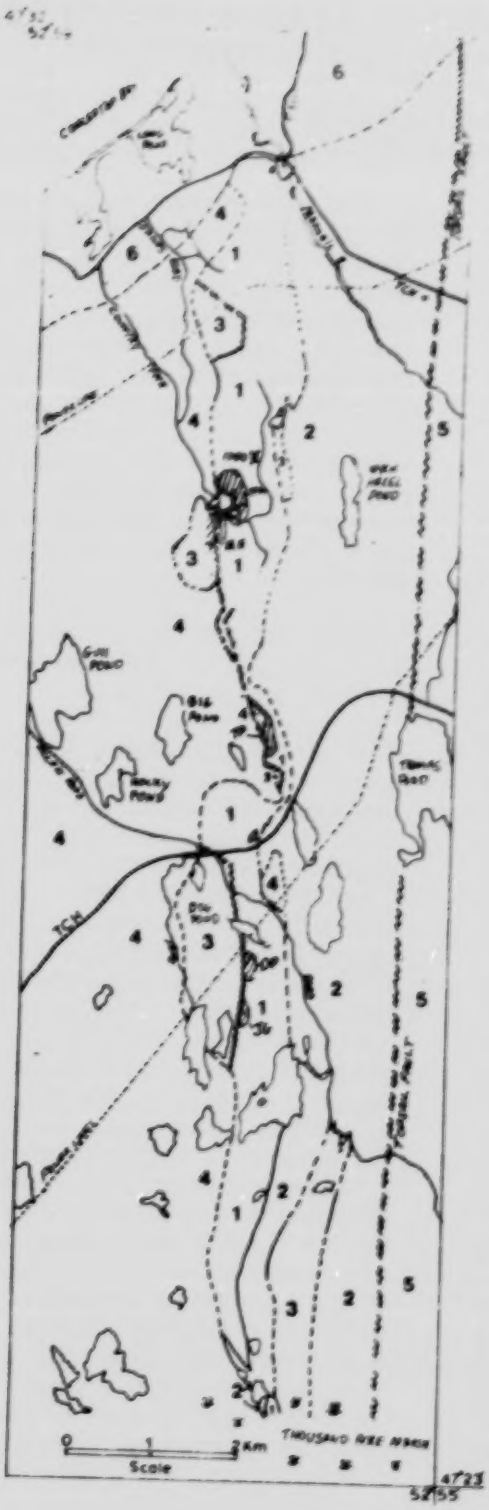

Figure 1. Regional Setting of the Eastern Avalon High - Alumina Belt

LEGEND

CAMBRIAN

undivided Adeyton and Harcourt Groups

6 shale, siltstone, and sandstone with conglomerate at base

unconformity

PRECAMBRIAN

Connaption Group

5 siltstone and sandstone (may be in part equivalent to Unit 3)

Holyrood Intrusive Suite

4 granodiorite and granite with minor feldspar porphyry

Harbour Main Group

3 siltstone and sandstone with local conglomerate

2 mafic volcanic, volcaniclastic and sedimentary rocks with locally interbedded felsic volcanic rocks

1 rhyolitic ash flow tuff, lithic and crystal tuffs; minor epiclastic rocks

Main Pyrophyllite Zones

OPM - Oval Pit Mine

MH - Mine Hill

TP - Trout Pond

DP - Dog Pond

JB - Jones Gully

Significant Gold Occurrence ✕
(value = conc. in ppb)

Geological Symbols

Fault (defined, approximate, assumed)

Contact (defined, approximate, assumed)

2) **Sericite Zone.** This is the most regionally extensive alteration facies developed. It has been documented by earlier workers to be marginal to the pyrophyllite zones and symmetrically disposed around it. Where multiple pyrophyllite zones are developed, as in the Oval Pit Mine, sericite zones are developed on a 5- to > 10-m scale, within the main pyrophyllite alteration. Outside of the pyrophyllite zones, sericite is the dominant mineral in schistose zones that characterize most of the intense alteration and deformation along the belt. The alteration is generally not so pervasive as to destroy primary volcanic textures, and lithophysae are commonly seen in a matrix of sericitized host rock.

3) **Silicified Zone.** Silicified zones are developed marginal to and within the pyrophyllite and sericite zones and also in relatively unaltered rocks. Primary textures are commonly destroyed. Features of hydrothermal activity such as brecciation and intense millimetre-scale quartz veining characterize many exposures. Silicified zones are developed on scales ranging from less than 1 to hundreds of square metres within felsic ash-flow tuffs, lithic tuffs and local conglomerates. The most intensely silicified rocks are white weathering, white to grey in colour and are very fine grained. These rocks are similar to those described from areas close to pyrophyllite and sericite-rich rocks in the Carolinas, where they have been called "quartz granofels" (Schmidt, 1985). The silicified rocks are commonly pyritiferous and in places contain 5 to 8 percent pyrite as disseminated grains (< 0.1 mm) and euhedral crystals (3 to 5 mm). A low grade (1 to 3 percent) pyrite mineralization is more widespread. It is within these zones that economic gold mineralization occurs in the Carolinas (e.g., Brewer and Pilot mountains; Schmidt 1985). A value of 1060 ppb was obtained on a narrow (< 2-m wide) silicified pyritized zone, adjacent to a 0.2-m wide quartz-haematite breccia vein near the Oval Pit Mine (Figure 1). Although gold data for most pyritized silicified zones are not yet available, further encouraging results from these zones are anticipated.

In addition to these main alteration types, there is considerable evidence for iron mobility throughout the system. Extensive haematite veining and pervasive haematization affects pyrophyllitized and relatively unaltered rocks within the main showings. Topaz has been tentatively identified in thin section as 2- to 3-mm subhedral to euhedral grains in the matrix of an altered boulder-cobble conglomerate from the Oval Pit Mine. It is partially replaced by pyrophyllite in some grains. Future petrographic and geochemical studies will focus on the distribution of alteration minerals within the system.

Efforts are currently underway by Atlantic Airways Ltd. to obtain multispectral data from the area using the Compact Airborne Spectrographic Imager (CASI) developed by Itres Research of Calgary, Alberta. The object is to evaluate the CASI as a prospecting tool.

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INDUSTRIAL-MINERAL STUDIES IN WESTERN NEWFOUNDLAND

Ambrose F. Howse
Mineral Desposits Section

In 1989, fieldwork on industrial minerals was carried out in a number of areas on Newfoundland's west coast (Figure 1). In the Bay St. George carboniferous subbasin, attention was focused primarily on gypsum. Several of the more significant prospects were mapped and sampled. Limestone and gypsum deposits on the Port au Port Peninsula were also briefly investigated, and some follow-up work was done on marble and dolomite prospects in both the Corner Brook region, and on the Great Northern Peninsula. Both, established, and new fledgling producers in industrial minerals were visited. These include the operating gypsum mine at Flat Bay, the developing limestone aggregate quarry at Lower Cove, the developing white marble quarry near Croque and the agricultural limestone operation at Cormack.

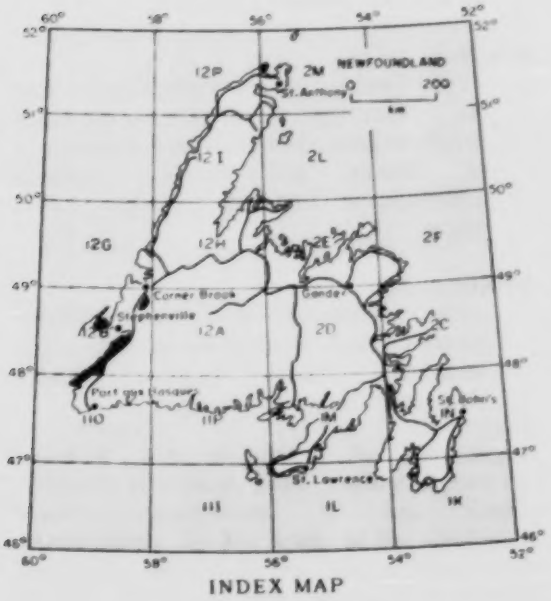

Figure 1: Project areas are outlined in black.

GYPSUM

Gypsum occurs throughout the Bay St. George carboniferous subbasin. It is found at four stratigraphic intervals in the Codroy Road and Robinsons River formations of the Codroy Group (Knight, 1983). The largest and most commercially attractive gypsum deposits are located in the northern part of the basin. These include the active Flat Bay Mine, and documented gypsum reserves at Fischells Brook, Romaines Brook, Sheep Brook and Coal Brook, all of which are held by Domtar.

The 1989 fieldwork clearly showed that the long-known (Baird, 1951; McKillop, 1959), although relatively unexplored region immediately east of Ship Cove, has considerable potential for large reserves of gypsum. Good quality gypsum is exposed in three major zones in the cliffs of Ship Cove, range up to 40 m in thickness and may extend inland for several kilometres. This is clearly evident when examining inland sinkholes and stream exposures of gypsum. The Ship Cove exposures were systematically sampled to determine the grade, type, and amount of impurities, especially NaCl. Unlike the relatively flat-lying deposit being mined at Flat Bay, the Ship Cove gypsum has been disturbed by folding and faulting that resulted in the repetition of beds and steeper dips. A carefully planned drilling program would be necessary to test the continuity and extent of the deposit.

Gypsum occurrences, in a belt of carboniferous rocks between Boswarlos and Piccadilly on the Port au Port Peninsula, were also examined and sampled. These showings are found on each end of the 5-km-long belt. Reconnaissance diamond drilling carried out by Flintkote Company Limited (1970), showed the gypsum occurence may be continuous. The present investigation, based

on the examination of several outcrops at the eastern end of the belt, indicates that the gypsum is comparable in quality to deposits in the Flat Bay area. The outcrops commonly are found in small hills and sinkholes. The white, grey and pink gypsum has a granular texture, and impurities consist mainly of black limestone fragments. The moderate dips and relatively thin overburden are positive features that add to the commercial potential of the gypsum.

LIMESTONE

Studies of limestone and dolomite deposits on the Port au Port Peninsula, by both government and industry, have proven the presence of large reserves of metallurgical and cement-grade stone. These deposits have yet to be developed. Large deposits of limestone at tidewater in Lower Cove have attracted the attention of developers and a new cement aggregate quarry will soon begin production for north American markets. Another potential use for Port au Port limestone is now beginning to emerge. It is standard practice to use limestone to absorb and retain SO_2 in fluidized-bed coal burning systems. An atmospheric fluidized-bed combustor burning 5 percent sulphur coal requires 0.5 kg limestone/kg coal (Hamer, 1986). In light of the tightening environmental regulations governing the emission of pollutants (mainly SO_2 and NO) from fossil-fuel-burning energy systems, this represents a potentially large market for limestone. Because Newfoundland's carbonate deposits have the advantage of being large and on the coast, this province may enjoy a competitive advantage. In 1989, in co-operation with industry, major limestone units on the Port au Port Peninsula were sampled to test their suitability as a reagent for flue-gas desulphurization (FGD). Much more work needs to be done to evaluate Newfoundland's limestone resources for possible use in pollution control systems.

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GRAPHITE, MICA AND HEAVY-MINERAL SANDS EXPLORATION IN LABRADOR

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In 1989, the field program consisted of exploration for graphite in western Labrador, sampling of mica pegmatites in western and southeastern Labrador and reconnaissance sampling for heavy-mineral placers in the Churchill River valley, west of Goose Bay (Figure 1).

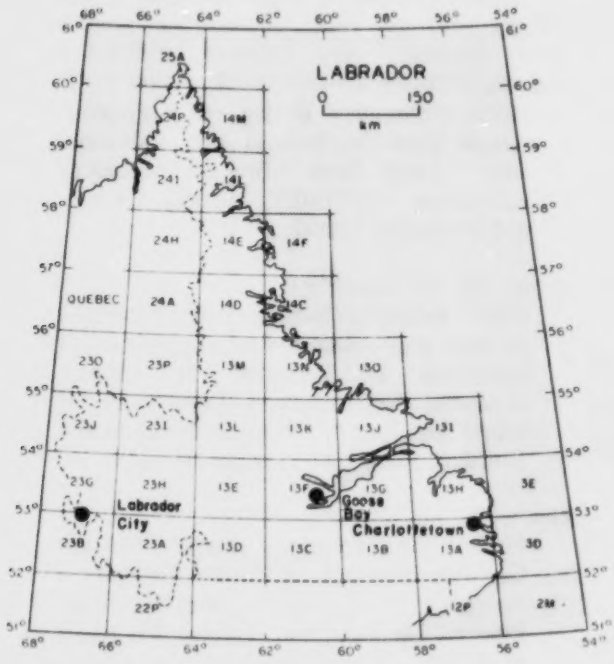

Figure 1. Location of study areas.

GRAPHITE

Exploration for graphite in western Labrador was stimulated by the recent discovery of a large, flake graphite deposit by Mazarin Incorporated at Lac Knife, approximately 30 km south of the Quebec - Labrador border. The 8.5-million-tonne deposit occurs in fine- to medium-grained quartzofeldspathic gneiss of the upper Knob Lake Group and averages 16 percent graphite, with 5- to 20-percent associated sulphides (Northern Miner, June 6, 1989, page 1).

A geophysical and prospecting survey was undertaken in the vicinity of Labrador City and Wabush, over areas underlain by the Menihek Formation (Knob Lake Group). This unit is known to contain graphite-bearing lithologies (Rivers, 1983). Combined VLF and magnetic ground surveys orientated perpendicular to strike, were completed, and representative rock samples collected. The most significant prospect is located 14 km south of Labrador City, 1 km west of Mills Lake. The area was investigated earlier by Labrador Mining and Exploration, who cut a grid (Mart Lake grid) and carried out geophysical surveys, as well as rock, soil, and lake sampling (Simpson, 1985). A 25-kg representative sample was obtained from a 15-m-long trench and sent to CANMET, in Ottawa, for preliminary benificiation work. The results of the preliminary analysis shows that the sample contains 41.9 percent carbon, and all flakes are finer than 300 µm (50 mesh)(Lamothe, 1989). The highest grade obtained was 81 percent carbon, in the -150, +71 µm (-100, +200 mesh) size fraction, which is considered as "small flake". Only 15.2 percent of the recovered graphite had flakes larger than 150 µm. As a consequence of the high-grade of the deposit, CANMET recommends that further field examination be undertaken, especially in consideration of the fact that gneissitic graphite ore bodies are not uniform in graphite content and aspect.

MICA

A mica prospect containing "ruled" muscovite crystals up to 25 by 15 cm, was previously reported to occur at kilometre 90 on the Trans-Labrador Highway (Meyer and Dean, 1988). This prospect is presently staked and exploration is underway to delineate its extensions. A second muscovite-bearing pegmatite was intersected by road construction this past summer at kilometre 137. In view of the small number of rockcuts on the Trans-Labrador Highway, this may suggest that there is a possibility of more pegmatites in the area.

Muscovite-bearing pegmatites have also been reported northeast of Charlottetown, in southeastern Labrador, by Gower *et al.* (1987). One of the better exposed pegmatites was staked this past winter by Mr. John Maderic, of Johnston, New York. An examination of this pegmatite was carried out, with Mr. Maderic, this past summer. The pegmatite forms a small ridge 4- to 5-m wide, having very large muscovite crystals concentrated on one side. Free-splitting books of sheet muscovite, up to 30 cm in diameter and 15-cm thick, were observed. High-quality sheet muscovite is used in the electronics and electrical industries.

HEAVY-MINERAL SANDS

The numerous rivers entering into Lake Melville, drain hinterlands underlain by gabbro-anorthosite massifs containing disseminated ilmenite, and granitoid and gneissic rocks having potential for zircon, rutile, and other heavy minerals (R. Wardle, personnel communication, 1989). "Black sand" lenses and laminations are known to occur in the extensive post-glacial deltaic, estuarine and littoral sands in the southwest end of Lake Melville. Sand and gravel terraces suggest that previous sea levels were up to 90 m above the present lake level, and tidal currents being active in the movement and redeposition of sediments (Kindel, 1924). Reconnaissance sampling of stratigraphic sections, through sand terraces along the Churchill River valley, was carried out this past summer. Black sand samples were also collected in the Goose Bay area by Fred Kirby, of the Mineral Lands Division, and submitted for analysis.

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METALLOGENY OF PERALKALINE FELSIC ROCKS IN LABRADOR: STRANGE LAKE PERALKALINE GRANITE AND LETITIA LAKE SHOWINGS

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INTRODUCTION

The rare-metal showings/deposits (Zr, Y, Nb, Be, REE), within the Strange Lake peralkaline granite and in the Letitia Lake area (Figure 1), have been the focus of an ongoing study, since 1984. The program for 1988-1989 included the analysis and interpretation of whole-rock geochemical and petrographic data, and the preparation of reports and presentations. The final reports for the above-mentioned study are provisionally titled: "The geology and geochemistry of the Strange Lake rare-metal deposit and the host peralkaline granite", and, " The geology and geochemistry of rare-metal mineralization in the Letitia Lake area."

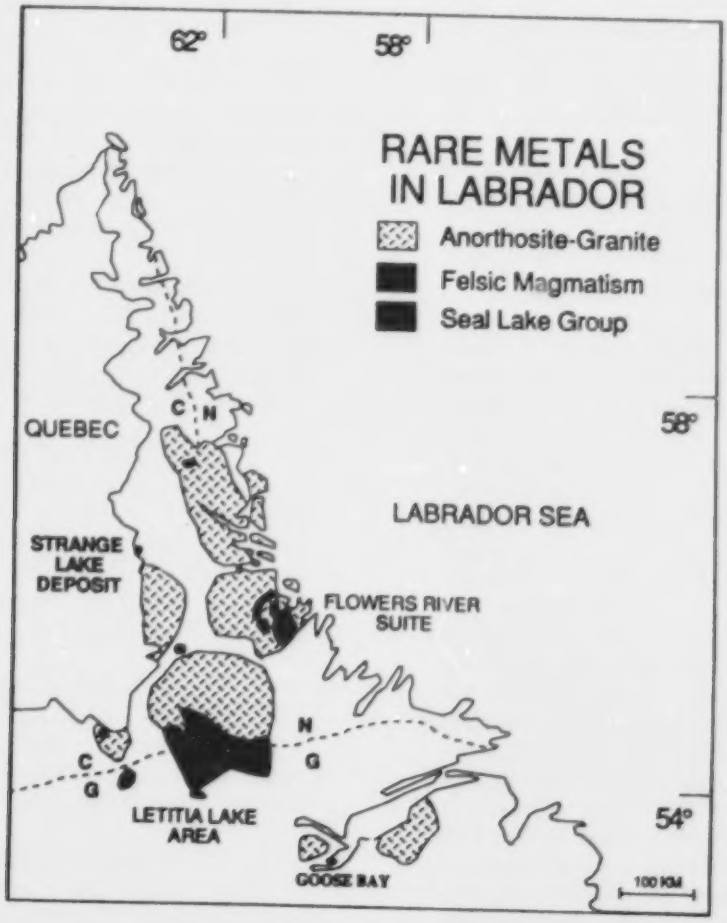

Figure 1. Location of the Letitia/Shallow lakes area, and the Strange Lake Deposit.

The Letitia Lake rare-metal showings (e.g., Mann #1 and Two-Tom Lake) and related felsic peralkaline host rocks are located in central Labrador, 290 km east-southeast of Schefferville, Quebec and 160 km northwest of Goose Bay, Labrador (Figure 1). The Strange Lake rare-metal deposit and its host peralkaline granite are located in northern Labrador (on the Quebec - Labrador border), 150 km west of the coastal village of Nain and 250 km northwest of Schefferville (Figure 1).

STRANGE LAKE RARE-METAL DEPOSIT

The focus of the study of this rare-metal deposit was on the geochemical, geological and petrographical description of the host peralkaline granite and the associated Ar-Y-Nb-Be-REE deposit. Interpretation of this data will help develop a metallogenic model for the formation of the Strange Lake type rare-metal deposit, and aid exploration geologists in the search for similar deposits.

Preliminary results of this work have been presented in Miller (1985, 1986a, 1988 and 1989). The final reports will expand and integrate the previously presented data as well as present new data and interpretations.

Recent studies of the Strange Lake deposit have focused on the pegmatite-aplite lens that hosts most of the high-grade mineralization in the deposit. These studies indicate that the main pegmatite-aplite lens at Strange Lake is petrographically, mineralogically and chemically zoned.

THE LETITIA LAKE RARE-METAL SHOWINGS

Work in the Letitia Lake area originally focused on the Mann #1 Nb-Be showing, but this led to an investigation of all of the rare-metal showings in the Red Wine intrusive suite and the associated Letitia Lake Group. These showings included the Mann #2, Michelin, and Two-Tom Lake Nb-Be+Y showings, the Ten Mile Lake Y showing and anomalous rare metals in the Shallow and Arc lakes peralkaline granites. The objective was to characterize these rare-metal showings and determine their metallogeny.

Preliminary results of the study of these showings have been presented in Miller (1986b, 1987, 1988 and 1989) and Batterson and Miller (1987). The final reports will present further detailed data and interpretations for the rare-metal showings.

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GRANITE METALLOGENY PROJECT

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During 1989, work on the Granite Metallogeny Project consisted mainly of writing and geochemical data compilation. Final reports on the Granite Lake and Cross Hills projects were submitted for publication, and work progressed on a final report of the White Bay area. Major findings are summarized below.

White Bay - Rattling Brook. Auriferous fracture stockworks, veins and shear zones are developed in granitoid rocks in the Rattling Brook area, western White Bay, Newfoundland (Figure 1). Associated hydrothermal alteration occurred in two stages. During Stage 1 (K-feldspathization) the host granitoid, a Proterozoic, foliated tonalite-granodiorite was hydrothermally converted to a granite *(ss)*, over an area of 2 km² in the vicinity of the mineralization. Stage 2 alteration (albitization) is restricted to stockwork fractures, veins and vein selvages

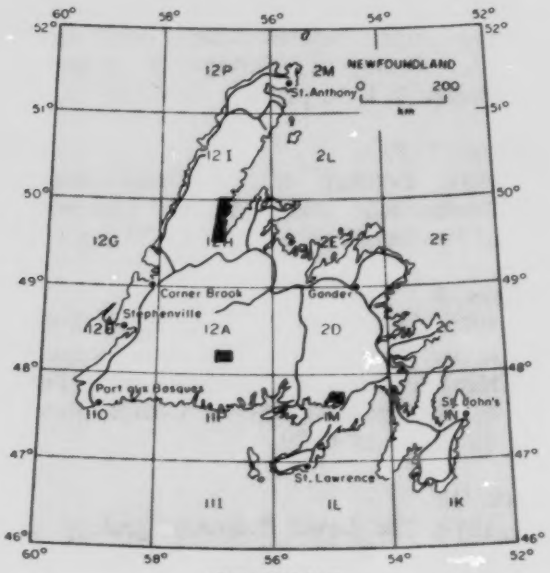

Figure 1: Location of study area.

and overprints both Stage 1 alteration and the unaltered rock. It consists of microcrystalline to fine grained albite containing lesser amounts of ankerite, quartz, sericite and siderite associated with pyrite, arsenopyrite and gold. Altered rocks are enriched in K, Na, Au, As, S, CO_2 and weakly enriched in W, Sb, and Br. Heavy rare-earth elements were removed during both Stage 1 and 2 alteration. Both alteration episodes are considered to be part of the same hydrothermal event, which resulted in formation of a large low-grade deposit. Stage 1 fluids initially permeated along grain boundaries and converted the host to granite. Subsequent increases in fluid pressure, aNa^+/aK^+ ratio and/or temperature, were accompanied by hydraulic fracturing, albitization and deposition of sulphides and gold during Stage 2.

A presentation on the Rattling Brook deposit was made at the Annual General Meeting of the CIMM in Quebec City in May, 1989 and a manuscript has been submitted to the CIMM for publication.

White Bay - Gull Lake. The Gull Lake intrusive suite is a series of granodiorite to tonalite, gabbro and diabase, megacrystic biotite granite and fine grained biotite granite that intrudes the Silurian Sops Arm Group, in the western White Bay area. Smyth and Schillereff (1982) proposed the name Gull Lake intrusive suite and defined and described the various phases. A zircon age of 398 Ma (P. Erdmer, personal communication, 1986) has been obtained from the granite phase. The Devils Room granite to the north, which is texturally and chemically similar to granites of the Gull Lake intrusive suite, has provided a zircon age of 398 +27/-7 Ma (Erdmer, 1986) supporting the idea that it is related to the Gull Lake intrusive suite (Lock, 1969). There is minor molybdenite and fluorite

mineralization in both the Gull Lake intrusive suite and the Devils Room granite (Tuach, 1987).

Geochemical analyses for the Gull Lake intrusive suite have been compiled. Analyses are available for the northern granite and granodiorite to tonalite phases (Smyth and Schillereff, 1982) and the Devils Room granite (Dunford, 1984). Several samples from the southern gabbro/diabase unit have also been analyzed. A report on this data is in preparation.

Cross Hills. The Cross Hills Plutonic Suite (Bradley, 1962; Tuach, 1984; O'Brien *et al.*, 1984) is a group of spatially and genetically associated gabbro to diabase, granodiorite, biotite granite, peralkaline granite and minor syenite intrusions, which outcrop over an area of 260 km² in the Terrenceville (1M/10) map area of southeast Newfoundland (Figure 1). The plutonic rocks intrude Late Hadrynian metavolcanic and metasedimentary rocks of the Long Harbour Group and give imprecise Rb-Sr ages around 560 Ma (Tuach, unpublished data).

The suite was intruded at a high crustal level in a northwest-southeast extensional tectonic regime, characteristic of the Late Hadrynian in the Avalon Terrane. Textural and geochemical data indicate that quenching due to loss of vapour pressure occurred across a geochemical boundary, within the magma chamber between a liquid of granite composition *(ss)* and a liquid of peralkaline granite composition. These data provide evidence for the existence of stratification in high-silica magma chambers.

The peralkaline granite phase of the Cross Hills Plutonic Suite is host to numerous small Zr-Nb-Y-REE mineral occurrences. The mineralogy of the occurrences and the distribution of mineralization in aplite dykes, tuffisite and fractures indicates a magmatic-hydrothermal origin. The peralkaline granite provided a source for the mineralizing elements that include Zr, Nb, Y, Sn, Th, Ce and heavy REE. Concentration and mobilization of these elements were aided by the prevalence of oxidizing, alkaline and possibly carbonate-rich fluids.

Granite Lake. Wolframite, molybdenite and native bismuth are found in sheeted quartz, quartz-greisen and quartz-pegmatite veins in an area of 25 km² between Granite Lake and Meelpaeg Lake. Mineralization occurs both within, and externally to the Wolf Mountain Granite, a massive, pink to red, muscovite granite *(ss)* of probable Late Silurian to Early Devonian age. The mineralization may be related to late north-northwest-trending and northeast-trending fault zones.

Alteration is focused on the north-northwest-trending fault zone. Feldspar is the most common alteration product, sericite is widespread, and kaolinite occurs locally. Geochemical data, including pervasive REE depletion, indicate that the granitoid rocks were extensively metasomatized during hydrothermal alteration.

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VOLCANIC GEOCHEMISTRY OF MASSIVE SULPHIDE DISTRICTS IN THE BUCHANS - ROBERTS ARM BELT

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Memorial University of Newfoundland[2]

As part of a continuing study of the regional metallogeny of the Buchans-Robert's Arm volcanic belt, mafic volcanic rocks associated with volcanogenic sulphide deposits at Buchans, Gullbrdige and Pilley's Island (Figure 1) have been systematically sampled and analyzed for major and trace elements. Selected samples were further analyzed for rare-earth elements (REE). Preliminary interpretation of the geochemical data is aimed at recognizing the tectonic environments represented by the volcanic rocks, characterizing and comparing the geological and tectonic settings in which volcanogenic sulphide mineralization occurred, and using this information for predictive metallogeny.

BUCHANS AREA

Thurlow and Swanson (1987) have recently redefined the stratigraphy in the Buchans mine area, based upon clear stratigraphic contacts in diamond-drill holes. Volcanic rocks were systematically sampled in drill core to assess the lithochemical variation in this geologically controlled, stratigraphically intact sequence.

All rocks in the sequence are calc-alkalic having characteristic island-arc signatures in their trace-element contents (Swinden *et al.*, 1989). There appears to be a geochemical discontinuity within the Sandy Lake formation; rocks in the upper part of this unit have slightly higher incompatible (e.g., TiO_2) element contents, flatter REE patterns and smaller negative Nb anomalies than those in the lower part of the sequence. Below this discontinuity, there is little discernable variation; basalts in the lower part of the Sandy Lake, Ski Hill and Lundberg Hill formations cannot be easily separated, geochemically. Samples from the bottom of the Sandy Lake and the top of the Ski Hill formations bracket the Buchans orebodies; there are no mafic volcanic rocks in the ore-bearing Buchans River formation.

GULLBRIDGE AREA

There are two significant volcanogenic sulphide deposits in this area, the Lake Bond and Gullbridge deposits. Geological evidence of structural complexity (Swinden and Sacks, 1986; Swinden, 1988) is also suggested by the complex geochemical patterns exhibited by the volcanic rocks. At least four distinct types of volcanic rocks can be recognized in this area:

1) LREE-enriched calc-alkalic basalts, some of which are geochemically similar to those in the Buchans sequence,

2) probably calc-alkalic basalts having flat to slightly REE-enriched REE patterns and arc geochemical signatures,

3) MORB-like basalts that lack arc signatures, and

4) strongly LREE-depleted tholeiites of uncertain origin.

Some of these types can be further subdivided. Commonly, two or three types occur within the same mafic volcanic map unit (Swinden and Sacks, 1986) suggesting that there is a complex structural interleaving of possibly unrelated volcanic rocks with these units.

PILLEY'S ISLAND AREA

Bostock (1988) assigned rocks in the Pilley's Island area to the Mud Pond - Boot Harbour Terrane, considered by him to comprise a calc-alkalic suite representative of

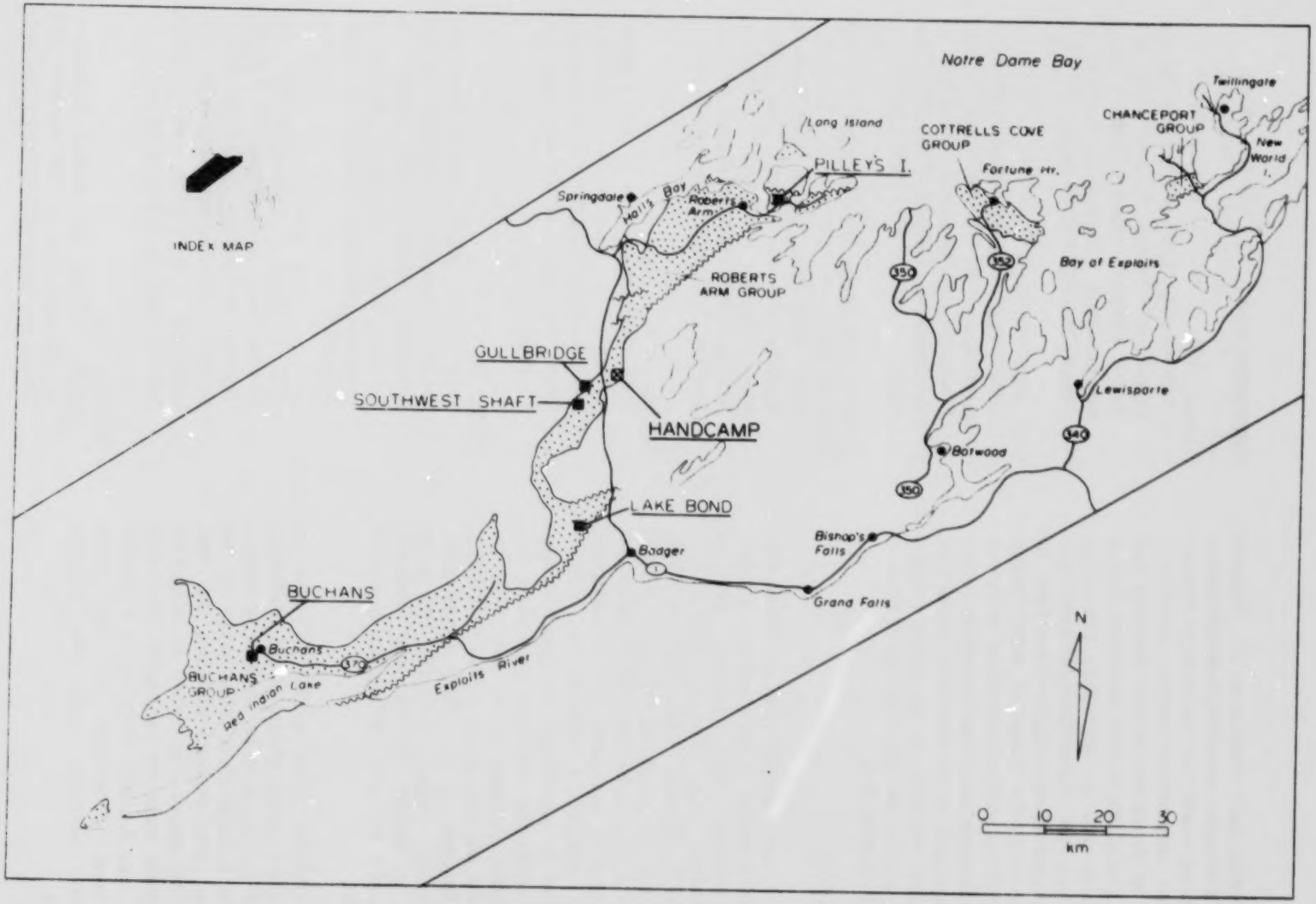

FIGURE 1. Buchans - Roberts Arm Belt, showing location of Buchans, Gullbridge and Pilleys Island.

an oceanic-arc environment. Because Bostock's analyses comprised mainly major elements, we re-analysed many of his samples as well as several new samples collected in the area by K. Hudson in 1988. Our new data confirm that rocks in the immediate Pilley's Island mine area are dominantly calc-alkalic with strong arc signatures. At least four distinct types of calc-alkalic basalt can be recognized on the basis of REE pattern shapes and the absolute abundance of various incompatible elements, two of which appear to be dominant in the immediate mine area. Calc-alkalic volcanics in the Pilley's Island area are similar, but not identical, to those in the Buchans mine area.

SYNTHESIS

Preliminary interpretation of whole-rock geochemical studies in the Buchans - Robert's Arm volcanic belt support previous interpretations (e.g., Strong, 1973, 1977; Dean, 1978; Bostock, 1988; Kirkham, 1988) of this belt as an ancient island-arc terrane. Mafic volcanic rocks that are spatially and stratigraphically associated with volcanogenic sulphide deposits at Buchans and Pilley's Island are all calc-alkalic, and geochemically similar, supporting previous suggestions that the sulphide deposits in the two areas are temporally and tectonically equivalent (Strong, 1977; Dunning *et al.*, 1987). Geochemical interpretations suggest that the two areas record a similar tectonic and volcanic environment, but subtle differences in magma processes.

Calc-alkalic rocks similar to those at Buchans are locally present in the Gullbridge area but do not show an obvious association with the mineralization. Most rocks in this area are LREE-depleted tholeiites that may not be arc-related. The extent to which arc and non-arc rocks are structurally interleaved in this area is under study, as is a detailed geochemical assessment of the rocks intimately associated with the sulphide deposits.

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REGIONAL GEOLOGY - LABRADOR

GEOCHRONOLOGY DATABASE - LABRADOR

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SCOPE AND OBEJCTIVES

Radiometric age-dating plays a major role in the interpretation of rock genesis and stratigraphic compilation. Based upon this premise, the Labrador Mapping Section has compiled a complete inventory of all age-dating results, obtained from rock samples collected in Labrador. On completion of the compilation, this database will be made available to any organization or member of the public, interested in Labrador geology.

The volume of available data has grown to the point that manipulation of information is best facilitated with the aid of a micro-computer database system, which enables manipulation based on a wide range of variables, whilst being reasonably "user friendly". The "Reflex" program of BORLAND ANALYTICAL was chosen, as being the most suitable, but data can be easily transferred to the relational database programs.

The database records the necessary information as reported within the geological literature, both published and unpublished. In order to maintain the objectivity of this database (within the constraints of a reference package), interpretation of this data has been kept to a minimum and is only provided where it is absolutely unavoidable. It is the intent of this publication to provide the most current information available. Wherever possible, the geologist who collected the data, or who is familiar with the geology of the area has assisted with the editing of the data.

It must be emphasized that the primary purpose of the database is as a quick and comprehensive reference to existing literature. It is not intended as a direct research tool. Consequently, the user is urged to refer to original publications for purposes of interpretation. A complete reference list of source material is available to the user who intends further statistical use of data.

Data will be available as paper copies or floppy disks in either ASCII text, or Reflex program files.

PROGRESS TO DATE

The database is in the final stage of editing and, to date, consists of 738 records.

The form design has been revised to best represent the data in paper presentation. Accompanying the database is a list of field names used, along with an explanation of entries made in each field.

Upon request, all data is available as individual records. Following final editing, all the records will be made available as a report in a ring binder format. An internal reference number, the catalogue number, has been assigned to each record. This will be the basis of arrangement of records within the binder. Accompanying the report will be three indices and a reference list. The indices provided will be based on, 1) regional mega-unit, 2) age, and 3) NTS sheet. Each will contain the following common fields: 1) catalogue number, 2) age, with positive and negative error margins, 3) isotope system and 4) regional mega-unit. Users requiring information categorized by any of the index topics need simply make note of catalogue numbers from the index, then refer to the main body of the report to find the appropriate records.

A complete reference list of all literature used throughout the database is provided at the end of the report. The list includes full references for both, source material, and most recently published maps showing the geology of the area from which the age dating data was collected.

Following publication of this document, periodic additions and revisions will be made. The ring binder formula will allow easy replacement and addition of records and indices.

EARLY AND MIDDLE PROTEROZOIC INTRUSIVE ROCKS IN THE EASTERN CENTRAL MINERAL BELT, LABRADOR: RECENT DEVELOPMENTS AND EVEN MORE RECENT SPECULATION

Andrew Kerr
Labrador Mapping Section

OVERVIEW

This project was initiated in 1985 to assess the mineral potential of granitoid rocks in east-central Labrador, and to gain an understanding of the anatomy and petrogenesis of rocks grouped under the general heading of "Trans-Labrador Batholith" in the Makkovik Province of Labrador (Figure 1). Previous reports (Kerr, 1986, 1987, 1988) have dealt mostly with the general geology and the identification and characteristics of potential specialized granitoid rocks.

No field work was conducted during 1988, and the project is now in the stage of final report preparation. Activity during 1988-89 was very limited, and restricted to completing a Ph.D. thesis based in part on results of the project. This thesis, entitled "Early Proterozoic granitoid magmatism and crustal evolution in the Makkovik Province of Labrador: A geochemical and isotopic study", was submitted to the Department of Earth Sciences at Memorial University. In addition to this thesis work, some preliminary work toward a final report (which will also emphasize the exploration geochemistry aspects of the project) was undertaken in early 1989. No field work was conducted during the 1989 season.

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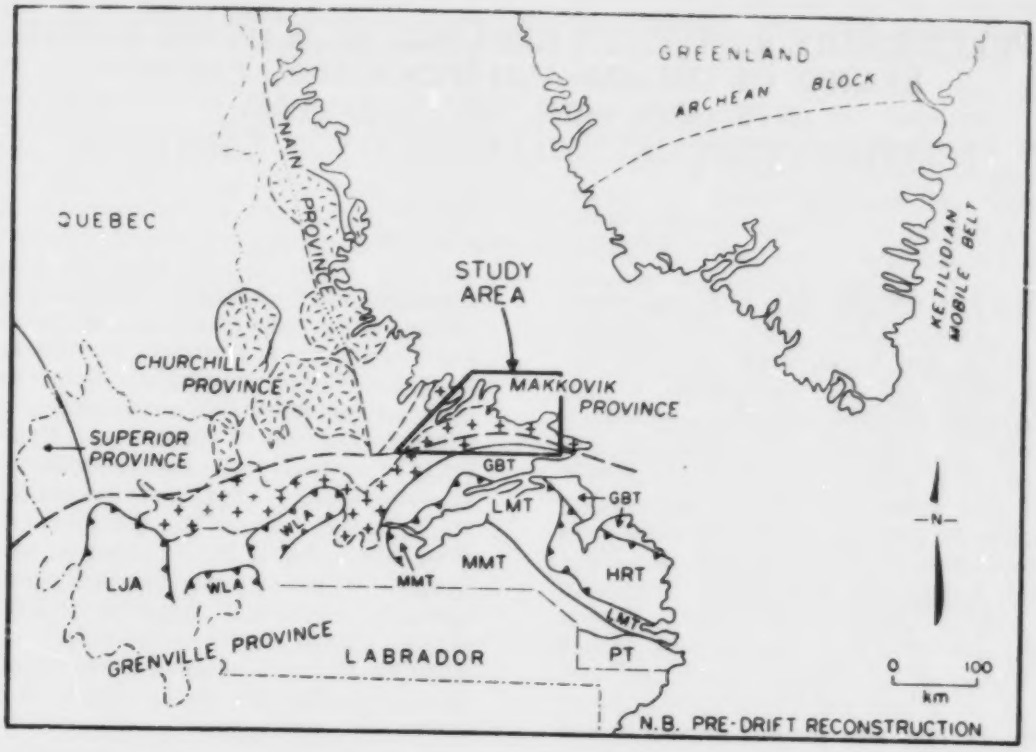

Trans-Labrador Granitoid Belt
(1850 - 1650 Ma)

Anorthosite-Granitoid Complexes
(1500 - 1300 Ma)

LABRADORIAN HIGH-GRADE TERRANES
(ca. 1650 Ma)

WLA - Wilson Lake Allochthon
LJA - Lac Joseph Allochthon
MMT - Mealy Mountains Terrane
LMT - Lake Melville Terrane
GBT - Groswater Bay Terrane
HRT - Hawke River Terrane
PT - Pinware Terrane

Provincial Border

Geological Boundary

Thrust Zone

Terrane Boundary

Grenville Front Zone
(Northern Boundary of
Grenvillian Deformation)

Figure 1. Principal geological elements of Labrador, showing the locations of the Trans-Labrador Granitoid Belt and the study area.

PRELIMINARY REPORT ON GEOLOGICAL MAPPING IN THE REGION OF WILSON AND WINOKAPAU LAKES, (NTS 13E/1, 13E/2, 13E/7 AND 13E/8) NORTHEASTERN GRENVILLE PROVINCE, LABRADOR

A. Thomas and P. Blomberg
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The four 1:50,000 scale NTS map sheets 13E/1, 13E/2, 13E/7 and 13E/8 mapped during July and August 1989, lie within the north-central part of that portion of the northeastern Grenville Province, which is exposed in Labrador. The mapping was carried out in conjunction with that of Wardle *et al.* (*this volume*) to the east, in order to complete the coverage of the unmapped areas between those done by Thomas and Wood (1983), Jackson and Finn (1982), Thomas *et al.* (1984), Thomas *et al.* (1981), Thomas (1981) and others farther to the west, as well as Wardle *et al.* (1988), Wardle and Ash (1986) and Wardle and Crisby (1987). Rocks within the map area are part of a crystalline plutonic - gneissic terrain, which is known to have undergone at least two distinct orogenic events: the Labradorian Orogeny ca. 1600 to 1700 Ma (Thomas *et al.*, 1986) and the Grenvillian Orogeny ca. 1000 Ma.

Nine regional lithological units are defined (Figure 1). Granulite facies Disappointment Lake quartzofeldspathic paragneiss (Unit 1A), is areally predominant and probably the oldest rock type within the region. It defines a wide, northeasterly trending highland massif exposed in the western three-quarters of the map area. Granulite paragneiss is intricately folded, contorted, and contains the assemblage sillimanite, biotite, hypersthene, magnetite, rare garnet, with or without sapphirine, cordierite and minor muscovite. Middle to upper amphibolite facies quartzofeldspathic paragneiss (Unit 1B), is considered to be a lower (possible retrograde?) equivalent of the granulite facies gneiss. It contains the assemblage sillimanite, biotite, garnet, abundant muscovite, with or without kyanite, and rare cordierite. Amphibolite facies paragneiss is migmatitic, contains much pegmatitic melt material such as bands, diffuse zones and dykes, and at numerous localities appears to grade into granulite facies paragneiss. Dykes, boudins and inclusions of mafic composition are commonly found within both grades of paragneiss. White, talc, tremolite, diopside-rich, calcitic marble (Unit 2) was originally noted by Stevenson (1969) at the eastern end of the Shoal River and along the Mouni Rapids section of the Churchill River. Several additional exposures, apparently confined to a narrow (< 0.5 km) arcuate band, were discovered during mapping, southeast of the confluence of the Shoal and Churchill rivers (Figure 1). The marble is well banded, with alternating siliceous and carbonate-rich layers, imparting to the dull-grey weathered surface, a distinctive relief. Deformed, variably metamorphosed bodies and sills(?) of gabbronoritic to leuconoritic composition (Unit 3) intrude the granulite paragneiss, north and west of Wilson Lake. One large body, northeast of Wilson Lake appears to grade with progressive deformation and metamorphism into Unit 4. Banded Beaver River basic orthogneiss (Unit 4), comprises ortho- and clinopyroxene, amphibole, garnet, feldspar and minor quartz. Although confined predominantly to a relatively narrow, northeast-trending body of minor areal extent in the Wilson - Winokapau lakes area, it is of much greater width in the adjoining region to the north. Several small, but economically significant bodies or xenoliths of pyroxene, magnetite, (olivine?)-bearing ultramafic rocks (Unit 5) are found widely distributed throughout the Unit 1a granulite paragneiss. Two of the larger ones occur respectively, southwest of Winokapau Lake and along the Trans-Labrador Highway, in the central part of the map area (Figure 1).

Several granitoid and gabbroid bodies of various sizes intrude units 1 to 3. The largest, most intensely deformed and probably oldest of these is poorly exposed along the eastern margin of the map area. Unit 6 consists of variably migmatized, banded to augen textured biotite, quartz, feldspar orthogneiss, which may have been derived from equigranular to porphyritic and/or megacrystic granite or granodiorite. It is medium to coarse grained, highly deformed and intruded by at least two generations of coarse, pink pegmatite dykes, one generation of which is moderately deformed. The Mouni Rapids pluton (Unit 7) intrudes granulite facies paragneiss east and southeast of the Shoal River. Although foliated throughout, with banding and augen textures predominating, distinct porphyritic and megacrystic textures have been locally preserved; evidence of an original plutonic igneous character. All of the Unit 2 marble exposures are within the confines of the Mouni Rapids pluton, although no contacts were observed. A narrow, deformed arcuate body of granitic to granodioritic composition, the Wilson Lake granodiorite (Unit 8), intrudes amphibolite facies paragneiss north and south of the Trans-Labrador Highway in the west-central part of the area. The body is foliated throughout, gneissic along its margins and exhibits porphyritic to megacrystic textures within its core. It is rich in both aplite and pegmatite, the former being particularly predominant in the body's northwestern section. In addition to intrusive contacts between the granite - granodiorite and Unit 1b amphibolite paragneiss, inclusions and xenoliths of polydeformed paragneiss were observed in the granite. The relationships between Wilson Lake granodiorite and other plutonic or metaplutonic bodies within the area are unknown. The youngest lithotype within the area is foliated gabbro to quartz gabbro (Unit 9), one small, poorly exposed body of which occurs north of the Trans-Labrador Highway within the eastern orthogneiss (Unit 6).

Rocks of the Wilson - Winokapau lakes area, exhibit a complex structural metamorphic history. Earlier, partly open to closed, isoclinal northeast-trending regional synforms and antiforms may be overturned to the southeast, with axial planes that dip toward the northwest at shallow to steep angles; the axial planes of these earlier structures tend to fan out. Later, east - west trending folds have axial planes that dip to the south at shallow to moderate angles and refold the earlier structures into complex dome and basin patterns. A number of late, ductile to brittle, east - west trending faults influence the drainage patterns of the Shoal and Churchill rivers systems. With the exception of Unit 1a paragneiss, which has undergone granulite facies metamorphism, all other units within the map area exhibit mineral assemblages and textures indicative of at least the middle amphibolite facies.

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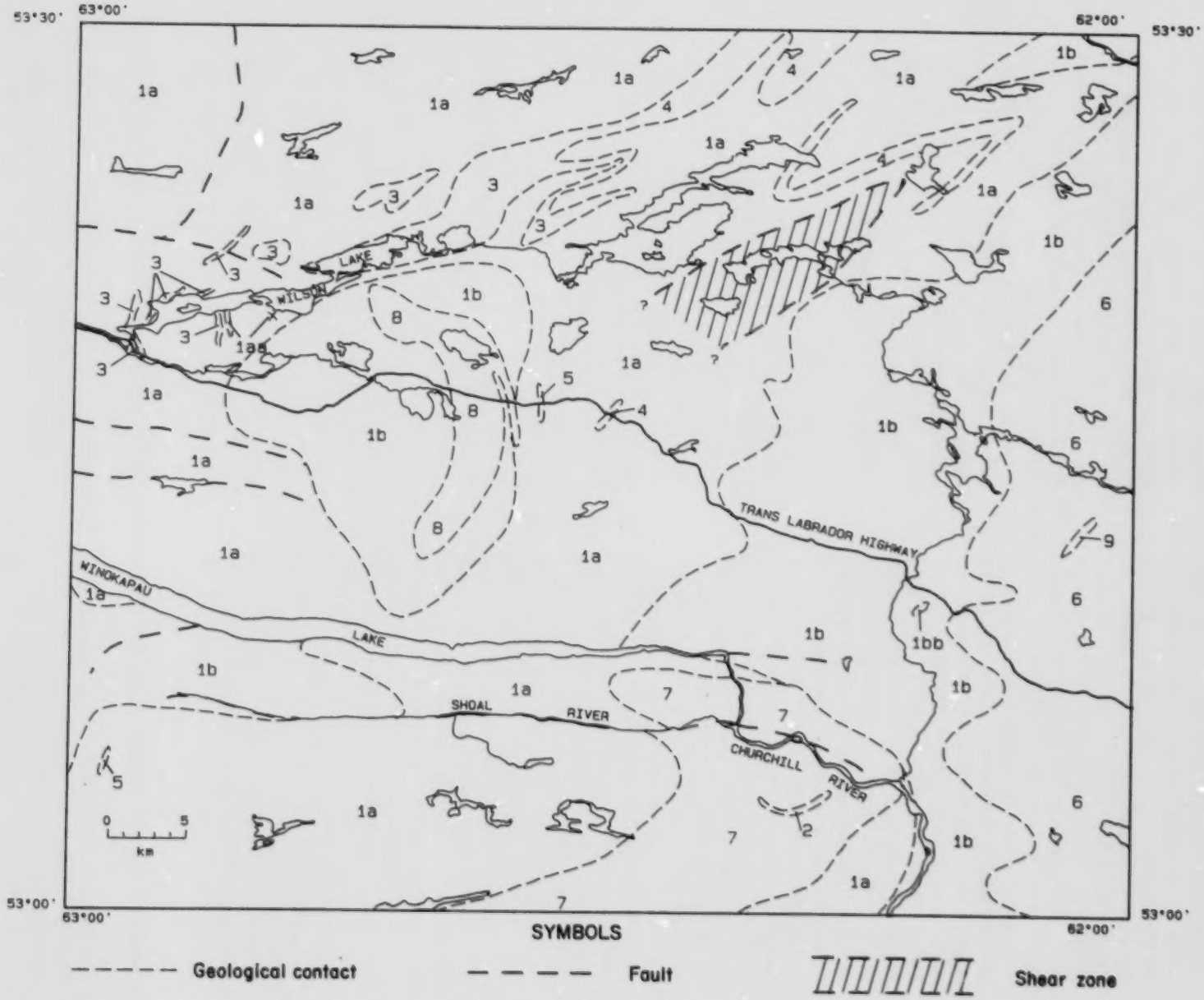

FIGURE 1. Geology of the Wilson and Winokapau lakes region.

LEGEND

PALEOHELIKIAN or OLDER

9 — Foliated gabbro and/or quartz gabbro.

8 — Wilson Lake granodiorite: foliated porphyritic to megacrystic granite/granodiorite, massive pink granodiorite, augen gneiss after porphyritic granite/granodiorite, biotite orthogneiss, aplite. Intrusive into middle to upper amphibolite Disappointment Lake paragneiss.

7 — Mouni Rapids pluton: foliated porphyritic to megacrystic granite/granodiorite and/or augen gneiss after megacrystic granite/granodiorite, minor quartz diorite, diorite and hornblende granite. Intrusive into granulite facies Disappointment Lake paragneiss.

6 — Banded to augen textured pink, migmatitic, biotite, quartz, feldspar orthogneiss after possible equigranular to porphyritic granite/granodiorite. Commonly intruded by coarsely crystalline pegmatite dykes.

APHEBIAN or OLDER

5 — Pyroxene, magnetite–bearing ultramafic rocks of unknown affinity.

4 — Beaver River gneiss: well banded basic orthogneiss containing orthopyroxene, clinopyroxene, amphibole, garnet, feldspar and minor quartz.

3 — Gabbronorite: massive igneous to metamorphic textured gabbro, quartz gabbro, norite and leuconorite intrusive into granulite facies Disappointment Lake paragneiss.

2 — Talc, tremolite, diopside and wollastonite?–bearing white marble.

1 — Disappointment Lake paragneiss: 1a; granulite facies quartzofeldspathic paragneiss containing sillimanite, biotite, hypersthene, magnetite and rare garnet with or without sapphirine, cordierite and minor muscovite. Contains numerous boudinaged mafic dykes and inclusions, rare oxide zones (1aa) and small intrusive bodies of charnockite and charnockite gneiss: 1b; middle to upper amphibolite facies quartzofeldspathic paragneiss containing sillimanite, abundant muscovite, biotite and garnet with or without kyanite and rare cordierite. Intruded by abundant deformed and undeformed, coarsely crystalline pegmatite dykes. Also contains zones of banded diorite to quartz diorite gneiss (1bb) and granodiorite melt.

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This volume: Geology of the Minipi River area (NTS 13C/NW), Labrador.

GEOLOGY OF THE MINIPI RIVER AREA (NTS 13C/NW)

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Labrador Mapping Section

This project is a continuation of the Goose Bay project, started in 1985, and is a 1:100,000 mapping survey of the central Grenville Province. Mapping was mainly helicopter supported, and carried out from a base camp on the Churchill Falls road. Outcrop exposure in the area is generally poor, due to a thick mantle of glacial and fluvioglacial sediment overburden.

The area contains the junction of two major tectonic terranes of the Grenville Province; these are the plutonic, Mealy Mountains terrane in the southeast, and metasedimentary gneiss of the Wilson Lake terrane to the northwest (Figure 1). Most of the rocks of these terranes were formed between *ca.* 1670 and 1630 Ma, and were varyingly reworked during the Grenvillian Orogeny (*ca.* 1000 Ma).

WILSON LAKE TERRANE

Metasedimentary gneiss, composed predominantly of banded, migmatitic quartz - feldspar - biotite - sillimanite gneiss, underlies the northwestern corner and contains small intercalations of amphibolite and mafic granulite. The metasedimentary gneiss is believed, by analogy with similar rocks to the north, to have formed *ca.* 1670 Ma. The gneiss contains several belts of strongly foliated K-Feldspar megacrystic granitoids, probably of intrusive origin.

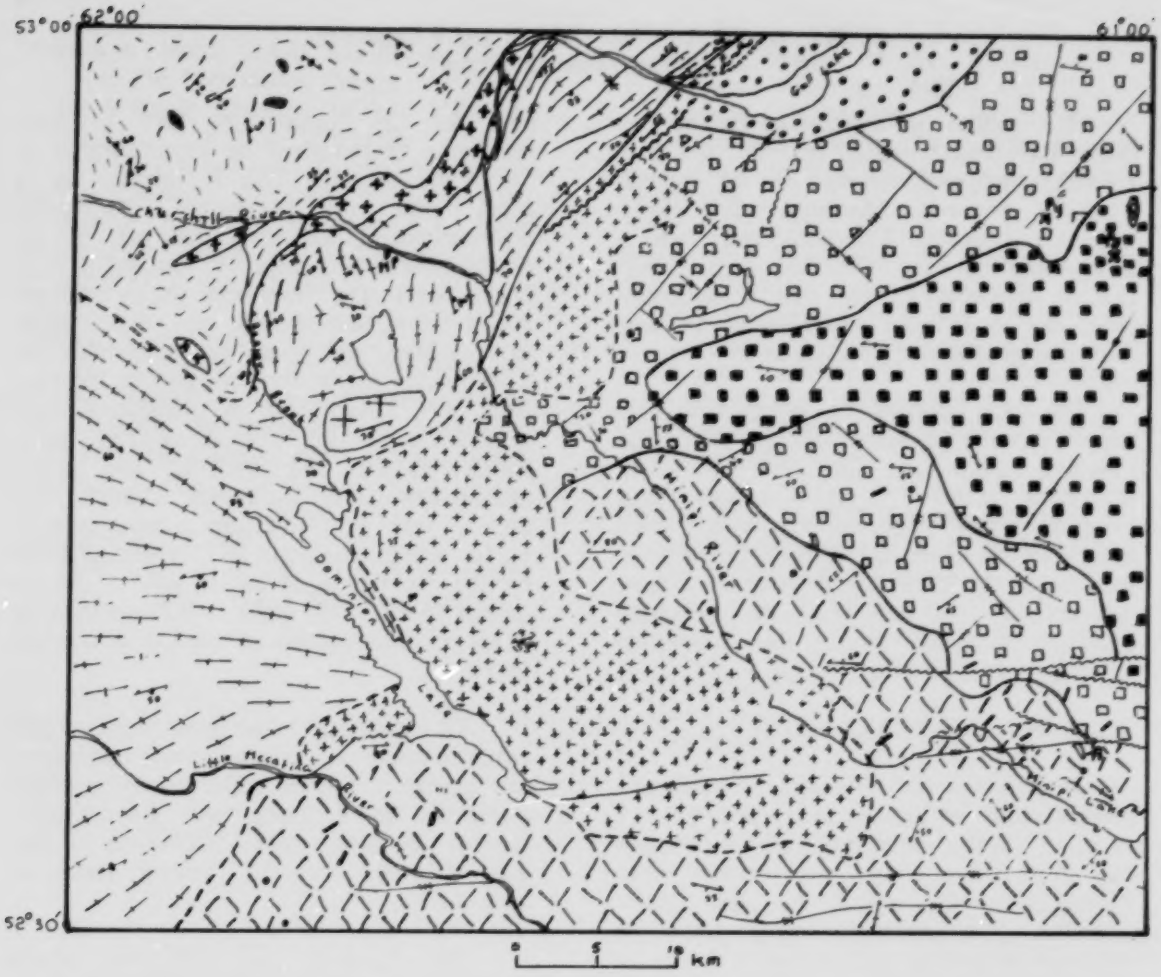
MEALY MOUNTAINS TERRANE

Plutonic rocks of the Mealy Mountains terrane underlie much of the southeastern survey area and consist mainly of undeformed to weakly recrystallized monzonitic to gabbroic lithologies. Generally, these are characterized by their dark-weathered appearance and the prevalence of clinopyroxene and biotite as the mafic component. The core of the terrane within the map area is formed by buff to grey monzonite characterized by inequigranular to porphyritic textures. This is intruded by a small unit of plagioclase porphyritic micromonzonite, indicating that part of the Mealy Mountains terrane was intruded at high crustal level. The monzonite grades outward into a mixed unit of dark grey, equigranular monzogabbro and biotite gabbro, gabbro and gabbronorite. In the southern part of the map area, this mixed unit is transitional into another varied unit comprising dark grey, biotite gabbro and gabbro, and lesser monzogabbro and monzonite. Overall, this unit is very similar to the monzogabbro - biotite gabbro unit, and is only distinguished by the prevalence of biotite gabbro. Biotite gabbro in all of the units is distinguished by large poikilocrystallics of randomly oriented biotite.

All monzonitic to gabbroic rocks contain minor amounts of syenite, quartz monzonite and granite as either differentiates or minor intrusions. In addition, they also contain, locally, abundant rounded inclusions of fine grained mafic rock in varying states of assimilation.

The western part of the Mealy Mountains terrane comprises granite, which is disposed within two lobes. The northern lobe consists of medium grained, strongly foliated pink biotite granite. The southern lobe, provisionally referred to as the Dominion Lake pluton, consists of coarse grained, inequigranular pink biotite granite in association with a medium grained equigranular phase. The pluton becomes increasingly foliated and, locally gneissic, to the northwest.

The plutonic rocks of the Mealy Mountains terrane also contain small, isolated enclaves of metamorphic rocks including agmatite and amphibolite schist.



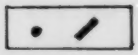
SYMBOLS

Geological contact / fault / or thrust : position inferred from aeromagnetic data.

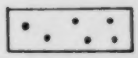
Air-Photo lineament

Figure 1. Geology of the Minipi river area.

LEGEND

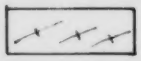


UPPER PROTEROZOIC - EARLY PALEOZOIC
Basalt, diabase and microgabbro dykes

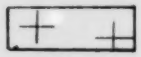


Area inferred to be underlain by **Double Mer Formation** sandstone and conglomerate

MIDDLE TO LOWER PROTEROZOIC
Mealy Mountains Terrane

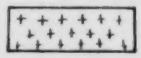


Lower Brook Suite: Pink granitic gneiss and lesser amphibolite. MP - meta-pyroxenite



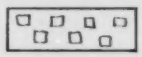
Foliated alkali feldspar granite

Plutonic rocks of Mealy Mountains Terrane



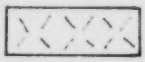
Pink biotite granite: **Dominion Lake pluton** - medium grained equigranular to coarse grained, inequigranular textured granite

Plagioclase porphyrytic micromonzonite



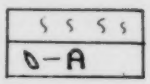
Buff to grey monzonite varying from equigranular to inequigranular and porphyrytic in texture: lesser monzogabbro and gabbro. Minor syenite, quartz monzonite and granite.

Grey equigranular monzogabbro varying to lesser biotite gabbro, gabbro and gabbronorite: minor monzonite, quartz monzonite, syenite and granite.



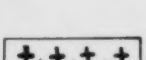
Grey biotite gabbro and gabbro, varying to lesser monzogabbro and monzonite. Minor syenite, quartz monzonite and granite.

Metamorphic enclaves within Mealy Mountains terrane plutonic rocks

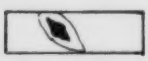


Agmatite of amphibolite and granite gneiss
Amphibolite schist and metagabbro

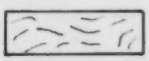
Wilson Lake Terrane



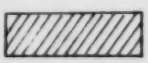
Strongly foliated, locally gneissic, K.feldspar megacrystic granite; minor granite gneiss.



granitoid gneiss



Migmatitic, quartz-feldspar-biotite +- sillimanite +- garnet metasedimentary gneiss. Locally also contains hypersthene and cordierite; minor amphibolite.



Amphibolite - mafic granulite

Pink granitic gneiss of the Lower Brook suite forms a broad swath separating the weakly deformed rocks of the Mealy Mountains terrane from the metasedimentary gneiss. Characteristically, the gneiss is a pink, migmatitic quartz - feldspar - biotite gneiss containing numerous bands and pods of black amphibolite. North of Dominion Lake, it contains a unit of foliated alkali-feldspar granite. Metamorphism of the Lower Brook suite is inferred to have occurred in association with Grenvillian overthrusting of the Mealy Mountains terrane over the metasedimentary gneiss.

Post-Grenvillian rocks are inferred to underlie a drift-covered lowland plain surrounding Gull Lake on the northern margin of the area. This plain forms part of the Upper Proterozoic - Early Palaeozoic Lake Melville Rift System, and is known to be underlain by red sandstone and conglomerate of the Double Mer Formation, to the northeast. Northeast-trending dykes of basalt, diabase and microgabbro found within the Mealy Mountains terrane are probably of similar age.

The major structural feature in the area is a Grenvillian ductile shear zone, characterized by development of straightened and mylonitic gneiss, located along the contact of metasedimentary gneiss and Lower Brook suite rocks (i.e., the Wilson Lake - Mealy Mountains terrane boundary). The northwesterly projection of the shear zone is not exposed and is based entirely on interpretation of aeromagnetic data.

The Mealy Mountains terrane displays a trellis pattern of joints and minor faults probably formed in association with the development of the Lake Melville Rift System. A belt of east to west oriented faults and photolinears across the southern part of the area is also a probable post-Grenvillian feature.

Previously reported mineralization is restricted to two occurrences of pyrite within monzonite and monzogabbro; however, the area has received only a minimal level of exploration attention.

REGIONAL GEOLOGY - NEWFOUNDLAND

INTEGRATION AND INTERPRETATION OF GEOCHEMICAL DATA FROM GRANITOID ROCKS OF INSULAR NEWFOUNDLAND: PRELIMINARY WORK DURING THE 1989 FIELD SEASON

Andrew Kerr
Labrador Mapping Section

OVERVIEW

Large-scale geochemical studies of granitoid intrusive rocks in Newfoundland have been undertaken for about 15 years, commencing with the study of Strong *et al.* (1974). Since then, systematic sampling has been carried out in a number of areas, both in conjunction with 1:50,000 geological mapping (e.g., Dickson *et al.*, 1989), and as separate studies aimed at specific plutons and related mineralization (e.g., Dickson, 1983). Systematic geochemical sampling programs are complete for most of the south coast of Newfoundland, between Fortune Bay and Burgeo. Plutons in the Gander and Avalon zones of eastern Newfoundland, and a few plutons in the eastern Dunnage Zone, were covered by the Strong *et al.* (1974) survey. However, the sampling density of this study is lower than in more recent surveys, and only a limited trace-element suite was determined. Outside of these areas, geochemical data is of variable density and quality, and comes from a variety of sources, including Department of Mines and Energy projects (e.g., DeGrace *et al.*, 1976; Hibbard, 1983), Geological Survey of Canada mapping and assorted thesis studies.

Despite the heterogeneity of these data, the estimated 4000 or more analyses represent one of the most complete databases for intrusive rocks that both spatially and temporally transcend the Appalachian orogenic cycle. Spatial geochemical variations may also be a powerful tool in locating and defining granophile mineral deposits, as shown by Tuach *et al.* (1986) in the Ackely Granite, or in defining later alteration systems where granites act as passive hosts to younger mineralization, as in western White Bay.

Accordingly, commencing in 1987, data from different projects was assembled into a master computer database, with the eventual objective of adding data from external sources (Butler, 1988). Starting in 1990-91, the next phase of the project will continue data assembly, but will also involve new field work and sample collection in many areas of the island, re-analysis of older sample populations to improve trace-element coverage, and a range of multidisciplinary studies coordinated with work funded by the LITHOPROBE EAST project. As a preliminary step, approximately four weeks of field work was undertaken in the 1989 season.

1989 SUMMARY RESULTS

The main objective of the field work was to become familiar with the characteristics and settings of the great variety of late Precambrian and Phanerozoic intrusive rocks in Newfoundland, primarily in easily accessible areas. Areas covered include the Baie Verte Peninsula, western White Bay, Fogo Island, the northeastern Gander Zone and Bay d'Espoir - Harbour Breton area, the Burgeo Road area and the area between Port aux Basques and Rose Blanche. A cooperative excursion with D. Bragg (*this volume*), as part of an aggregate assessment, allowed visits to most of the south coast granites by helicopter.

A start was made on establishing a reference collection of large, representative samples from individual plutonic complexes and phases within them. These will be slabbed, stained, photographed and archived, and will form an initial sample suite for isotopic and mineral chemistry studies. A reference collection of this type will be useful in the classification and comparison of units

and also in an economic sense, as many granites may ultimately be more valuable as dimension stone or aggregate resources than for their intrinsic mineral potential.

Sampling was also carried out for isotopic studies. A number of bulk samples, many from reference localities, will be analyzed for Nd, Sr, Pb and O isotopic characteristics by B.J. Fryer and co-workers at Memorial University and elsewhere. Some new geochemical sampling was carried out in areas where data is presently lacking, but this was not of a systematic grid-based nature. A number of bulk samples were also collected from reference localities for U - Pb zircon dating.

FURTHER WORK

Assembly and organization of geochemical data will continue as far as is possible, and a large portion of the 1974 sample population will be re-analyzed for a complete trace-element suite. Some small-scale field work may be conducted on the Avalon Peninsula in late October. Samples collected in 1989 will be submitted for geochemical analysis.

ACKNOWLEDGMENTS

I thank Lawson Dickson for his friendship and invaluable guidance and advice during this summer's work, and Dan Bragg for his cooperation in getting us to south coast granites in exchange for our views on potential aggregate units. Vincent Peckham provided capable and good-natured help during both field and office work.

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TRILOBITE BIOSTRATIGRAPHY OF THE COOKS BROOK FORMATION (NORTHERN HEAD GROUP), HUMBER ARM ALLOCHTHON, BAY OF ISLANDS, WESTERN NEWFOUNDLAND

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INTRODUCTION

The Cooks Brook formation is a sequence dominated by deep-water carbonate gravity deposits, which forms part of the Humber Arm Allochthon. It comprises approximately 350 m of grey-black shale and lime mudstone interstratified with carbonate conglomerate. Originally defined by Stevens (1965, 1970), the Cooks Brook formation was subsequently restudied by Botsford (1988a, b). During the field survey, previously unreported late Middle Cambrian to Early Ordovician trilobite faunas were collected from this deep-water carbonate slope deposit (Botsford *et al.*, 1986).

PREVIOUS WORK

Schuchert and Dunbar (1934, page 90) were the first to collect trilobites from the Cooks Brook formation. They identified *Agnostus* and *Triarthrus* from limestone conglomerates exposed south of the mouth of Serpentine River. Kindle and Whittington (1965) subsequently collected additional (Late Cambrian to Early Ordovician) trilobite material from Schuchert and Dunbar's locality and re-identified their *Triarthrus* as "*Bienvillia*" sp. cf. "*B.*" *corax* (Billings). They also obtained Franconian (middle Late Cambrian) trilobites from apparent Cooks Brook formation strata exposed on the White Rocks in Bear Cove, 10 km north of Serpentine River. Dr. R. K. Stevens (Memorial University of Newfoundland) later obtained late Middle Cambrian *Bathyuriscus - Elrathina* Zone trilobites from the Cooks Brook formation along Humber Arm (Botsford, 1988a; Botsford *in* Cawood *et al.*, 1988, page 56).

PRESENT WORK

In 1984, 1985 and 1986, the authors collected approximately sixty fossiliferous samples from the Cooks Brook formation of Humber Arm, Middle Arm and Penguin Arm. Trilobite species indicative of the following zones have so far been identified:

early Early Ordovician (Early Canadian, Gasconadian Stage)
  Symphysurina Zone (Ross - Hintze Zone B)
  Missisquoia Zone (Ross - Hintze Zone A)
late Late Cambrian (Trempealeauan Stage)
  Saukia Zone
middle Late Cambrian (Franconian Stage)
  Taenicephalus Zone
early Late Cambrian (Dresbachian Stage)
  Crepicephalus Zone
  Cedaria Zone
late Middle Cambrian
  Bolaspidella Zone
  Bathyuriscus - Elrathina Zone

Additional Late Cambrian zones may be recognized when the trilobite collections are studied further.

BIOSTRATIGRAPHIC CORRELATION

Trilobite species indicate that the Cooks Brook formation ranges in age from the late Middle Cambrian *Bathyuriscus - Elrathina* Zone to the Early Ordovician *Symphysurina* Zone (Ross - Hintze Zone B). The Cooks Brook formation therefore correlates with James and Stevens' (1986) beds 0 to 8 of the allochthonous Cow Head Group. It also broadly correlates with the autochthonous March Point and Petit Jardin formations (Port Au Port Group) and the Watts Bight Formation (St. George Group).

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REGIONAL GEOCHEMICAL TRENDS IN THE BURGEO INTRUSIVE SUITE, GAULTOIS, FRANÇOIS AND CHETWYND GRANITES, SOUTHERN NEWFOUNDLAND

W.L. Dickson and S.J. O'Brien
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The Siluro - Devonian Burgeo intrusive suite, the largest batholith in southern Newfoundland, comprises early foliated, K-feldspar-porphyritic biotite granite, medium grained biotite - muscovite granite and post-kinematic, coarse grained biotite granite plutons. The Silurian Gaultois granite is similar to the earliest phase of the Burgeo intrusive suite. The Devonian Chetwynd and François granites are composite high-level granites that have intruded all the older units and the major tectonic structures such as the Dragon Bay and Bay d'Est faults and the Grey River shear zone. Regional lithogeochemical studies of the Burgeo intrusive suite and adjacent granites in the Burgeo region, indicate that the geochemical patterns correlate with the various components.

Selected elements and oxides from the granites were plotted at 1:250,000 scale, using GEOSOFT contouring programs (see Figure 1). Geochemical variation of major elements such as SiO_2 and CaO indicates that the François and Chetwynd granites are distinctly more evolved than most of the Burgeo intrusive suite and the Gaultois granite. Similar characteristics are shown by trace elements such as Sr and Cu, which are sensitive indicators of differentiation. All the granites are potassic but the late granites are even higher, having over 5 percent K_2O. The various rock types within a suite are best indicated by a combination of trace elements and element ratios. The ring structures in the François granite are indicated by U, Pb, Rb, Li and others. Within the Burgeo intrusive suite, the biotite - muscovite granite is indicated by low Cu and higher Rb and Li. Internal variations within the Chetwynd Granite are not apparent on the trace-element plots, although the topographically higher parts of the pluton are more silicic.

Element enrichment and depletion patterns indicate that some parts of the region have potential for granite-related mineralization. Parts of the Burgeo intrusive suite are enriched in Mo and one multi-point anomaly coincides with known molybdenite mineralization. The centre of the northeastern lobe of the François granite is enriched in U, F, Pb, Rb and Li and depleted in Th and Sr, and presents the best target for mineralization. Several isolated Cu anomalies correlate with the more mafic parts of the Burgeo intrusive suite. A series of Cu anomalies occurs along a 15-km belt, 16 km north of Burgeo. This belt coincides with the early porphyritic biotite granite. The eastern anomaly also corresponds with a Pb anomaly.

The major shear zones are not highlighted by the element distribution maps although silicification and alteration are common. However, some anomalies, e.g., Th, do coincide with the faults.

Figure 1. Contour map of uranium in whole-rock granite samples. Higher values are lighter tones; generally > 12g/t=white.

MAPPING AND STRATIGRAPHIC STUDIES AND ECONOMIC POTENTIAL OF CAMBRO-ORDOVICIAN CARBONATE ROCKS OF THE GREAT NORTHERN PENINSULA, WESTERN NEWFOUNDLAND: AN UPDATE

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Mapping of the autochthonous, Cambro - Ordovician, dominantly carbonate rocks of the Humber Zone on the Great Northern Peninsula has been almost completed. This work, begun in 1976, involved 1:50,000 scale mapping, detailed stratigraphic studies and micro- and macro-biostratigraphic studies. It has led to the establishment of a firm stratigraphy for the 1600 m succession, a basic understanding of geological events and sedimentary settings of large- and small-scale sequences that comprise the Newfoundland platform, and the stratigraphic framework of base-metal and industrial commodities in the area.

Paleontological and biostratigraphical studies describe a preliminary trilobite zonation for western Newfoundland. This latest Early Cambrian to early Middle Ordovician zonation, may eventually prove to be (at least partly) applicable to other areas of the Appalachian - Caledonide Orogen. To date, the studies have enabled numerous correlations to be made at specific level.

Shelf accretion at the Lower Paleozoic continental margin was the result of the interaction of subsidence, the interplay of various scales of sea-level rise and fall, sedimentation rates and tectonic activity. The margin evolved in three distinct stages: 1) a long-lived (about 75 Ma), passive margin stage lasted from the middle Early Cambrian to Early Ordovician and includes sedimentary rocks of the Labrador, Port au Port and lower St. George groups; 2) the short-lived second stage (about 5 Ma) occurred during the transition from passive to convergent margin settings. It involved rocks of the upper part of the St. George Group and culminated in the formation of the St. George Unconformity; and, 3) the third stage (about 10 Ma), includes only carbonates and shales of the early Middle Ordovician Table Head Group and accumulated at a tectonically unstable, convergent margin. Sediments of the passive margin and the middle transitional stage are for the most part shallow water, reflecting several, mostly eustatic, events of shelf drowning and subsequent sedimentary progradation that produces megacycles (100's of metres) of subtidal, followed by peritidal, "half-cycles". The carbonates deposited toward the end of this period were affected by tectonic instability upon the platform as a peripheral bulge impinged upon the continental margin. The St. George Unconformity, is a regional unconformity having widely developed surface and subsurface karst, and evidence of faulting and brittle fracturing of Lower Ordovician carbonates before and during this episode of subaerial exposure. The convergent margin sediments consist of an upward-deepening sequence, which resulted from the downwarping and collapse of the margin, as Taconic subduction and orogenesis destroyed the margin.

Generally, each transgressive - regressive cycle in western Newfoundland is characterized by its own distinct trilobite faunal succession; further, within each succession, discrete trilobite biofacies are recognized. This is particularly true in the Middle Cambrian and Early Ordovician sequence. For example, it has been found that lime wackestones and boundstone mounds generally contain different trilobite species associations, from each other. Because nearshore, shallow-water shelf faunas and offshore, deeper-water shelf faunas can be distinguished by biofacies analysis, it is a

useful tool for outlining major facies belts, and paleogeographic reconstructions, which may prove to have some economic significance.

The platformal sequence begins with a basal mixed siliciclastic and carbonate sequence (the Labrador Group), which is an onlap - offlap sequence that was laid down, following Early Cambrian marine flooding of the continental margin. A succession of K_2O-rich shales and relatively pure quartz arenites deposited respectively during the onlap - offlap phases of this mega-sequence are high-tonnage commodities in the northwest of the area.

The succeeding Port au Port Group is a Middle to Late Cambrian succession of dominantly low-energy, peritidal fine-grained dolostones and shales that accumulated in the inner part of a narrow shelf, behind a belt of carbonate sand shoals. The dolostones were deposited after Middle Cambrian transgression and subtidal limestone deposition. Dolomitization of the upper part of the Middle Cambrian limestone provided a suitable host for minor sphalerite and galena mineralization. The same minerals are also hosted, locally, by fracture porosity and structurally controlled breccias in the lower part of the overlying dolostones.

Lower Ordovician carbonates are the host to the main base-metal deposits of the area but also contain hugh reserves of industrial stone. The St. George Group consists of two mega-cycles, comprising lower subtidal carbonates followed by overlying "half-cycles" of peritidal carbonates that culminated in each mega-cycle in a regional disconfor- mity. The succession beneath the disconformities was modified by subsurface diagenesis in two important ways. Firstly, strata-bound dolomitization replaced all or large parts of the subtidal carbonate "half-cycle", probably by subsurface mixing of meteoric and saline waters during the deposition of the upper "half-cycle" and during subaerial exposure. Secondly, widespread dissolution produced extensive networks of rock-matrix breccia bodies, that probably represent subsurface karst collapse breccias. Emplaced into the dolomites and mostly adjacent to these breccias are a number of sphalerite ore bodies, that include the producing mine at Daniel's Harbour (in the upper megacycle), and the Round Pond prospect (in the lower megacycle). The dolomites of the upper megacycle are up to 60-m thick and provide hugh tonnages of low-silica, metallurgical-grade rock for agricultural and industrial purposes.

Where the subtidal limestones of the lower "half-cycle" are not affected by the dolomitization, large tonnages of good quality, pure, metallurgical limestones are preserved in both megacycles. Characteristically light grey to white, these limestones are typically peloidal carbonate sands, microbial mounds and fenestral. They occur in thick, massive beds that suggest that the microbial mounds having spectacular depositional fabrics and fossils would make high-quality decorative stone. Locally, the same limestones and some pure limestones from the top of the underlying Cambrian carbonate sequence are metamorphosed to high-grade marble deposits in parautochthonous thrust slices near Canada Bay and Hare Bay. Assessment of the economic potential of these marbles and pure limestones as mineral fillers is presently underway by several companies.

The Table Head Group is a succession of peritidal carbonates, overlain by subtidal limestones and shales that reflect the collapse and drowning of the margin during the early stages of Taconic orogenesis. The basal peritidal limestones include a succession up to 50-m thick of thick-bedded, light grey limestones; these limestones include fossiliferous and fenestral carbonate sands and mudrocks. They are both pure and massive suggesting that they have potential, both as metallurgical limestone and as a decorative stone.

GEOCHRONOLOGY DATABASE - NEWFOUNDLAND

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SCOPE AND OBJECTIVES

Isotopic age dates provide the necessary quantitative time constraints in determining stratigraphic successions/temporal structural events, on a regional basis; however, this information is widely scattered in the published and unpublished proprietary literature. The objective of this project is to provide researchers with a readily available index to all of the information on age determinations for insular Newfoundland and this project has collated this information into a single, easily accessible database.

The uses for the database are wide-ranging. It may be used to undertake simple searches on fields such as: unit name, author or age, and the computer disk copies (of the database) can be manipulated with other software, to interpret geochronological patterns. Users of the database are urged to check the original source for confirmation of data and to evaluate the merits of particular data.

The database contains age determinations based on the commonly used isotopic systems: K-Ar, Rb-Sr, Sm-Nd, Ar-Ar and U-Pb. In an attempt to be objective, all of the publicly available age determinations, whether published or unpublished, are included. This allows the user to decide on the validity of a particular date.

DATA ACCESSIBILITY

The database is available as a paper copy. It will also be available, if requested, on floppy disk as a text file, a Borland Reflex file under MS-DOS or as a Double Helix file under Macintosh.

Each of the age dates provided is presented as a single record (Figure 1). The form is divided into sections having the most relevant information at the top of the record for quick reference, followed by the supplementary information in the other sections. The records are assigned catalogue numbers and are arranged in numerical order.

The indices provided in the paper copy are essential for data searching. There are five indices sorted on the following fields: major unit, minor unit, age, NTS sheet, and tectonostratigraphic zone. The users can search the appropriate index for a specific age determination and will then be referred to a catalogue number.

The open file will be periodically updated as new age determinations become available.

8027	**GREY RIVER ENCLAVE**	**579 ± 10 Ma**
1989	Gander Zone	U/Pb
		Proterozoic/Cambrian

Location

Latitude: UTM northing: 5268700 Approximate location: Grey River Point.

Longitude: UTM easting: 491000

NTS sheet: 11P/11 UTM zone: 21

Field Data

Minor unit: Grey River Gneiss

Rock type: Gneiss Amphibolite facies

Laboratory Data

Material dated: Titanate Interpretation: Cooling

Type of plot: Lower Intercept Age as originally published: 579 ±10 Ma

Initial ratio: Decay constant(s) used in original publication: 9.85×10^{-10}, 1.55×10^{-10}

MSWD: Laboratory: Royal Ontario Museum, Toronto

Comments

This age determination records the time of cooling through the post-metamorphic blocking temperature. This sample also yielded a zircon crystallization age of 686+33/-15 Ma, see catalogue number 8026. The gneiss contains coarse angular titanate fragments.

References

Sample or reference number: NF-86-001
Map reference for location: (Figure 2, Dunning and O'Brien, 1989; Dickson *et al.*, 1984a).
Author reference: Dunning and O'Brien (1989)

Figure 1: A sample record from the geochronology database - Newfoundland, showing the various fields

LATE PRECAMBRIAN GEOLOGY OF THE NORTH SHORE OF BONAVISTA BAY (CLODE SOUND TO LOCKERS BAY)

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Recent geological investigations, east of the Dover Fault in northwest Bonavista Bay, provide new insights into, 1) the depositional history of the Late Precambrian (Avalonian) rocks, 2) the nature and timing of deformation and magmatism, related to Late Precambrian and mid-Paleozoic orogeny, and 3) the relation of mineralizing events to the region's tectonic and intrusive history.

Major northeast-trending faults, regionally parallel to the main Dover Fault zone, divide this region into distinct domains. Despite widespread faulting, critical relationships amongst major stratigraphic units are preserved. The oldest rocks are variably strained, greenschist facies volcanics (Love Cove Group) dated at 620 ± 2 Ma. This lithologically diverse suite of submarine, and in places subaerial, eruptive rocks is characterised by a continuum of compositions between rhyolite and basalt. These rocks are intruded by pre- and posttectonic diabase dykes, small pretectonic quartz diorite - granodiorite plutons, and younger posttectonic granites of Precambrian and probable Devonian age. The group, in general, is more shistose than the adjacent rocks.

Rocks that lie along strike of, and are continuous with the Love Cove Group type area (at Clode Sound) are gradationally overlain by a thick (≥ 4 km) succession of marine siliciclastic sedimentary rocks (Connecting Point Group). In most areas, the contact with older volcanics is marked by a major structural break, which embodies the northward continuation of the Paradise Sound Fault and related structures. This tectonic line demarcates the western limit of extensive marine sedimentation in the Avalon Zone and the eastern limit of the major Late Precambrian volcano - plutonic arc that is the principal geological feature of the west half of the zone.

Volcaniclastic lithic arenites, which dominate the Connecting Point Group, are mainly the product of sedimentation adjacent to an active volcanic arc, the remnants of which form the Love Cove Group. The volcaniclastic apron of sandstone, siltstone, shale, tuffs and pebbly mudstones records an upward evolution from basinal shale - pyroclastic association, through channel-levee dominated submarine fans into pelagic sediments. Renewed development of submarine fans, signifying important basin extension, resulted in widespread deposition of thin- and thick-bedded turbiditic sandstones.

These turbidites are overlain by terrestrial clastic and bimodal volcanic rocks (Musgravetown Group). Their contact is marked by an angular unconformity that is exposed at Clode Sound, Cutler Head, Southward Head and Long Islands. The main outcrop area of the Musgravetown Group lies east of the Connecting Point Group and, with the above exceptions, in fault contact with it. A smaller outlier lies east of and in fault contact with the Love Cove Group and unconformable upon the Connecting Point Group. A western belt of Musgravetown Group rocks is bounded by the Bloody Reach and Howses Cove faults. These rocks separate the main belt of the Love Cove Group from similar lithologies underlying the area between the Howses Cove and Dover faults. The relation of the latter rocks to Musgravetown Group clastics is enigmatic. If the contact is a fault, then the present assignment of the volcanics to the Love Cove Group may be correct; if it is conformable, then the volcanics must be part of the Musgravetown sequence. The eastern and western areas the of Musgravetown Group are affected by many steep faults and large-scale (Acadian) folds that involve fossiliferous Cambrian strata and their probable equivalents.

An alluvial conglomerate - sandstone unit forms the base of the Musgravetown Group, intervening between Connecting Point turdidites and an extensive bimodal volcanic complex. The latter is disconformably overlain by distinctive wispy-bedded shallow-marine and fluvial sandstones that coarsen and redden upward into boulder conglomerate. These are succeeded by shallow-marine sandstones and quartz arenites. The above sequence is characterised throughout by rapid facies changes and pinch-outs. Rhyolite from the base of the Musgravetown Group has been dated at 570 +5/-3 Ma. These volcanics are enriched in Nb, Zr, Y and Zn, relative to the older Love Cove Group volcanics and display commenditic and pantelleritic affinities.

The Louil Hills intrusive suite, which is a bimodal intrusive suite marginal hybrid phase, contains a posttectonic riebeckite granite, dated at 572 +3/-2 Ma. The peralkaline granite and related felsic dykes have anomalously high concentrations of rare-earth elements, and are interpreted to be comagmatic with Musgravetown Group volcanism. Peralkaline and strongly alkaline compositions are now considered to be signatures of post-Avalonian, Precambrian magmatism. Granite, gabbro, and glomeroporphyritic and porphrytic diabase dykes of the suite, intrude and thermally overprint previously foliated sub-Musgravetown strata on the inverted limb of a northwesterly inclined, overturned regional syncline. The data confirms Precambrian deformation of sub-Musgravetown Group rocks on the northwest margin of the Avalon Zone, and brackets this deformational event between ca. 620 Ma and 570 Ma.

It is suggested that many of these deformational features are genetically related to late Precambrian faults, which may have been reactivated by Acadian strike-slip movements. The zone-bounding Dover Fault may have been sited along such a structure. The faults may represent pathways for mineralizing fluids and may be important in metallogenic modelling. It is noteworthy that the major fault that marks the volcanic arc - sedimentary basin interface in much of the area is the site of widespread silicification, sulphide mineralization and elevated gold concentrations.

A NEW MAP OF THE REGION SOUTH OF THE BAY D'EST FAULT (PARTS OF NTS 11O/9,16 AND 11P/12,13), SOUTHWEST NEWFOUNDLAND

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The region is underlain by plutonic, stratified and metamorphic banded rocks of Precambrian to Devonian age (Figure 1), which are disposed in generally northeast-trending belts and bounded by younger intrusions and/or faults. The oldest dated rocks are regionally extensive bodies of variably deformed, blue-quartz-bearing tonalite and granodiorite that give U-Pb zircon ages, as old as the Late Precambrian. Equigranular to porphyritic, blue-quartz phyric tonalite and granodiotite, correlated with the Roti Granite, intrude amphibolitic gneisses and schist (Cinq Cerf gneiss) and lower grade sedimentary rocks (Whittle Hill sandstone). These Precambrian intrusions and associated amphibolitic gneiss complexes are widespread and found in several fault blocks southeast of the Bay d'Est fault. The relation of the Whittle Hill sandstone to the Cinq Cerf gneiss is obscured by the Roti Granite, which separates both units.

In the northeast, a thick succession of low-grade sandstone and conglomerate associated with volcanic intercalations (La Poile Group), unconformably overlies a dated Precambrian granodiorite body intrusive into amphibolitic gneiss. These low-grade clastics, which occur in two separate basins, contain distinctive volcanic units that can be cross-correlated and are dated as Silurian. Also of Silurian age, are gabbro, quartz - feldspar porphyry, granodiorite, granite and mafic dykes that were intruded during various stages of the regional Silurian deformation. Most of these rocks intrude above and below the sub-Silurian unconformity. However, the oldest synkinematic granites are preferentially intruded near faults separating Precambrian basement and Silurian cover. Devonian magmatism is represented only in the posttectonic, high-level Chetwynd Granite and related satellite intrusions.

The Precambrian and Silurian rocks occur in at least three major thrust sheets truncated by Devonian granite. From northwest to southeast, the bounding faults of these thrust sheets are: the Bay d'Est, Cinq Cerf and Grand Bruit fault zones. Silurian stratified rocks occur in a thrust sheet bounded by the Bay d'Est and Cinq Cerf fault zones. Within this thrust sheet, the Silurian strata typically occur on the long northwest-dipping limbs of upright folds. However, at the margins of the thrust sheets, the folds are inclined to the southeast and highly strained beds are inverted. In two localities to the northeast, the sub-Silurian unconformity is preserved within the thrust sheet bounded by the Cinq Cerf and Bay d'Est faults. In these areas, the thrusts occur in sub-La Poile Group basement; elsewhere the basement/cover contact is defined by these structures. In the central part of the region, the Cinq Cerf and Bay d'Est faults merge, and basement rocks intervene between the Silurian basins, where the former are enveloped by Silurian and Devonian plutons.

Low-grade strata of inferred Precambrian age (Whittle Hill sandstone), intruded by the Precambrian Roti Granite, occur in a thrust sheet bounded by the Grand Bruit and Cinq Cerf faults. Unlike the Bay d'Est and Cinq Cerf structures, the Grand Bruit fault zone is readily identifiable only in the southwestern part of the region, where it is crosscut and truncated by Silurian and Devonian granites, respectively. However, in the northeastern part of the region, the Grand Bruit thrust may occur within the amphibolitic basement gneiss that crops out as partially digested, inhomogenously deformed, gently dipping enclaves within the early synkinematic granites. Alternatively, the Cinq Cerf and Grand Bruit fault zones may have merged in the area presently occupied by Devonian granite.

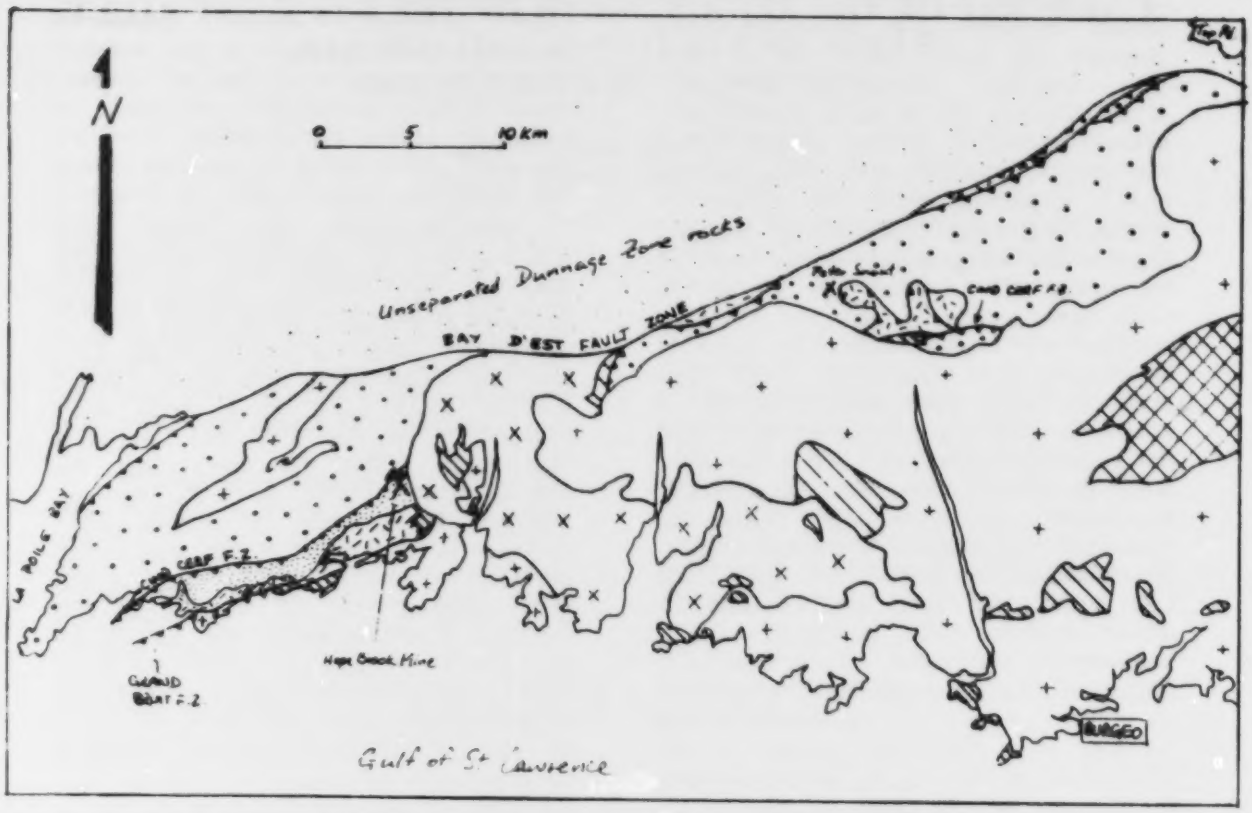

Figure 1. Study area of the region south of the Bay d'Est Fault, southwest Newfoundland.

The Hope Brook gold mine (hosted by sub-La Poile Group basement) and the Peter Snout gold - base-metals prospect (hosted by La Poile Group cover) are both located along the trace of the Cinq Cerf fault zone. The Peter Snout prospect occurs in the footwall of the fault, and this implies that some of the mineralization associated with the Cinq Cerf fault zone is Silurian. The Hope Brook mine occurs in the hanging wall of the Cinq Cerf fault zone and the main mineralizing event may be either Silurian or earlier. If the gold mineralization in the Precambrian basement at Hope Brook predates the deposition of the Silurian cover, then the Cinq Cerf fault zone is neither the sole nor earliest control on mineralization. Instead, proximity to the older Grand Bruit fault zone and related pre-Silurian intrusions may be the fundamental regional control on gold mineralization in the basement complexes.

LEGEND

DEVONIAN

Chetwynd Granite

SILURIAN

Unseparated Silurian intrusions

La Poile Group

ORDOVICIAN

Unseparated granite, porphyry and gabbro

ORDOVICIAN ? OR EARLIER

Unseparated orthogneiss, paragneiss and gneissic granite

PRECAMBRIAN

Roti granite

Whittle Hill sandstone

Cinq Cerf Gneiss and associated rocks (locally includes unseparated younger intrusions)

PROVENANCE OF THE CONNECTING POINT GROUP

Tomasz Dec
Newfoundland Mapping Section

As a continuation of the work on the provenance of the marine, volcaniclastic deposits of the Connecting Point Group, a limited number of 30 detrital clinopyroxene grains, sampled from the upper part of the succession close to the "mixtite" horizon, were examined by microprobe analysis. The aim of this investigation was to define clearly, the affinity of at least some of the magmas, represented in the pyroclastic deposits. The results obtained agree with the earlier suggestions made by Knight and O'Brien (1988) and Dec *et al.*, (1989), based upon the sedimentological and petrographical evidence that the voluminous pyroclastic and epiclastic, intermediate to felsic sediments, which accumulated in the Eastport basin, were derived from a mature island-arc complex. However, the major-element chemistry of the augites and endiopsides provides a much more rigorous constraint on the origin of the volcaniclastic material because it indicates a calc-alkaline affinity of the magmas, and points to an orogenic, island-arc setting for their eruption. Further microprobe and petrographic work will be done on additional samples collected this summer (1989), from the vicinity of the mixtite horizon, to substantiate the initial results.

Also, during the summer, bulk chemistry data on volcanics from the Love Cove Group were determined. These data will be integrated into the results of the clinopyroxene microprobe investigations to develop and establish a broader picture of the Late Precambrian volcanism of the Avalon Zone.

In August, as part of a separate study, sampling of sandstones and conglomerates from the La Poile Group, Rogersons Lake Conglomerate, Jonathans Pond formation, Indian Bay formation and Davidsville Group were carried out. The objectives of the study are to determine source areas for these rocks, and to resolve specific problems regarding timing of geological events in the adjacent drainage basins. Also, clast counts in the field, paleocurrent measurements and general sedimentological observations have been made in the La Poile basin.

As a result of detail petrographic, SEM, and preliminary microprobe work, abundant detrital chrome-spinel has been identified in the fossiliferous (Early to Middle Ordovician) limestone conglomorate, which outcrops within the Spruce Brook Formation (Mount Cormack Subzone), and in the volcanogenic conglomerate of the Davidsville Group. In spite of the absence of ultramafic rock fragments, the detrital chromite, often preserved as euhedral grains, has most likely been derived from the local ophiolite complexes of Great Bend and/or Pipestone Pond (Dunnage Zone). If this is indeed the case, the finding will have significant implications regarding timing of emplacement of the ophiolite complexes of the Dunnage Zone, and their relationship to the Mount Cormack Subzone.

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GEOLOGY OF THE NORTHEAST GANDER LAKE MAP AREA (NTS 2D/15) AND NORTHWEST GAMBO MAP AREA (NTS 2D/16)

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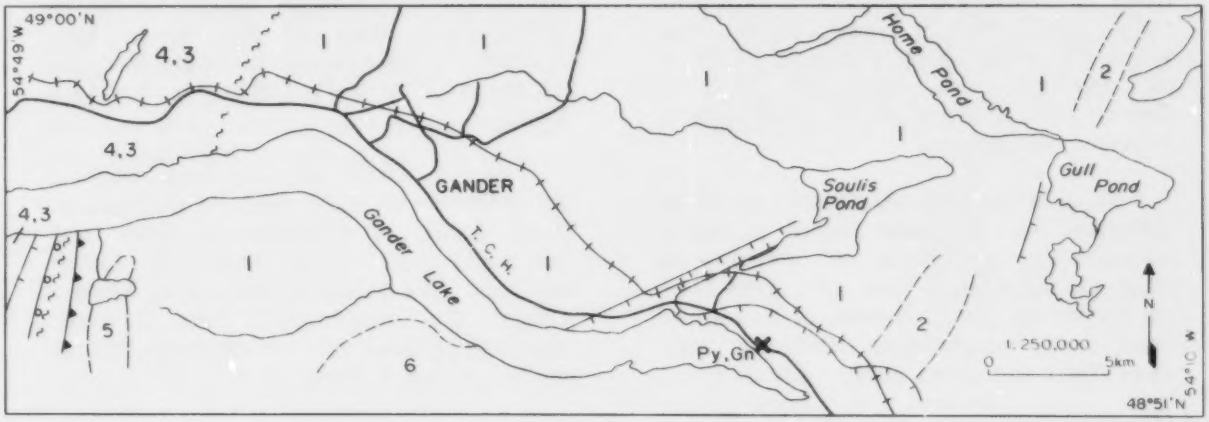
INTRODUCTION

During the 1989 field season, the northeast corner of map area 2D/15 (Gander Lake), and the northwest corner of map area 2D/16 (Gambo) were mapped at a 1:50,000 scale (Figure 1).

This project represents a continuation of the mapping of the Gander Zone, initiated by Blackwood (1977).

GEOLOGY

The area is underlain mainly by metasedimentary rocks of the Gander Group.



LEGEND

SILURO-DEVONIAN

6 GANDER LAKE GRANITE
5 MIDDLE RIDGE GRANITE

ORDOVICIAN

4 DAVIDSVILLE GROUP

ORDOVICIAN OR OLDER

3 GANDER RIVER COMPLEX

GANDER GROUP (Units 1 and 2)

2 INDIAN BAY BIG POND FORMATION
1 JONATHANS POND FORMATION

SYMBOLS

Approximate geological contact.....
Fault.....
Biotite isograd.....
Garnet isograd.....
Andalusite isograd.....
Mineral occurrence..... X
Pyrite..... Py
Galena..... Gn

Figure 1. Geology map of the northeast Gander Lake and northwest Gambo area.

On the western side, sedimentary rocks of the Davidsville Group are (structurally) imbricated with igneous rocks of the Gander River complex. In the western part of the area mapped, north of Gander Lake, the approximate trace of the contact between the Gander River complex and the Gander Group is marked by a lineament along most, if not all, of its length. However, south of Gander Lake, a lineament is not associated with the contact between the two.

The best exposures, of all units, occur on the north and south shores of Gander Lake. North of Gander Lake, exposures of gabbro, mafic volcanic rock or ultramafic rock occur within the Gander River complex. Much of the ultramafic rock, north and south of Gander Lake, is altered to talc ± carbonate ± serpentine assemblages.

North of the lake, the Davidsville Group comprises fine- to coarse-grained sandstone, conglomerate and black to greyish-green shale. On the southern shore of Gander Lake, the Davidsville Group consists of interbedded black shale, conglomerate containing black shale flakes and quartz and/or feldspar grains, dark grey, medium- to coarse-grained sandstone and brownish sandstone. Several hundred metres from the westernmost exposures of the Gander Group, recesssive-weathering calcareous layers and lenses, generally thin (< 10 cm), are interbedded with greenish-grey sandstone. A white rock, containing distinctive bright green layers, probably rich in chromium muscovite, occurs in one locality. South of the lake, exposures of the Davidsville Group are scarce and mostly represented by black shale.

Generally, the area is underlain by metasedimentary rocks of the Jonathans Pond formation. This formation consists of interbedded quartz-rich sandstone varying from fine- to coarse-grained, quartz granule sandstone characterized by blue quartz grains and greyish-green siltstone and pelite. Concordant mafic bodies, typically a metre thick but up to several metres thick, occur commonly throughout the Gander Group. On the north shore of Gander Lake, immediately east of exposures of altered ultramafic rock of the Gander River complex, the Gander Group consists of interbedded black, dark grey and green shale and grey sandstone. These rocks pass gradationally eastward into grey sandstone and greyish-green pelite of the Jonathans Pond formation.

Approximately 2 km west of Wing Pond, exposures of red siltstone and red and grey pebble to cobble conglomerate occur, and are assigned to the Indian Bay Big Pond formation. The well-rounded cobbles consist predominantly, if not entirely, of fine- to medium-grained psammite. Several kilometres farther south, north of the railway line, exposures of black laminated pelite occur and are also assigned to the Indian Bay Big Pond formation.

Biotite, garnet and andalusite isograds are defineable in rocks north of Gillinghams Pond. Biotite is developed in pelitic and semipelitic rocks of the Davidsville Group and garnet and andalusite occur in the Gander Group. The metamorphic grade increases apparently toward the northern extension of the Middle Ridge Granite.

Most of the rocks mapped in the north-west part of map area 2D/16 are low-grade greenschist facies. On the west side of Wing Pond, the rocks of Jonathans Pond formation appear to increase markedly in metamorphic grade eastward. Locally, kyanite occurs in schist on the west side of Wing Pond.

On the shores of and southeast of Gull Pond, rocks of the Jonathans Pond formation increase in metamorphic grade toward the Middle Brook Granite. These metamorphic rocks are characteristically coarse-grained and schistose.

West of Benton, on a southeast-facing escarpment, rocks of the Jonathans Pond formation achieve andalusite grade in a narrow zone, approximately 1-km wide, that extends northeast from the Trans-Canada Highway to Soulis Pond. South of Benton, in Trans-Canada Highway roadcuts, and on the north shore of Gander Lake, rocks of the

Jonathans Pond formation are metamorphosed to amphibolite facies. This metamorphism appears to be related to the Gander Lake granite.

ECONOMIC GEOLOGY

The most significant mineralization found during the field season, occurs within quartz-rich sandstone in a fresh roadcut on the Trans-Canada Highway, just east of the Benton junction. The mineralized zone is approximately 7-m wide and is characterized by disseminated and vein pyrite and galena. The mineralization is post-development of the main tectonic foliation in the rocks because it locally follows the solution seam cleavage. Extensive sericitization occurs in places within the rusty zone. On the eastern edge of the zone, a galena-rich vein occurs and varies between 2 cm and less than 1 cm in width. This mineralization may be related to the Gander Lake granite, which is nearby.

In the Gander Group, north of the Trans Canada Highway, pyrite-rich quartz veins occur sporadically and locally form small gossans.

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GEOCHEMISTRY/GEOPHYSICS

MAPPING THE REGIONAL DISTRIBUTION OF GOLD IN NEWFOUNDLAND USING LAKE SEDIMENT GEOCHEMISTRY

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The distributions of Au and related elements, such as Sb and As in organic lake sediment, not only reflect the majority of known gold occurrences in Newfoundland, but also delineate new areas and geological environments having gold potential, thereby providing new exploration targets. Lake sediment samples had been collected throughout the island of Newfoundland at an average density of 1 site per 7 km² between 1973 and 1982. These regional surveys were conducted primarily to assess base-metal and uranium potential, and the samples were initially analyzed for Ag, Co, Cu, F, Fe, Mn, Mo, Ni, Pb, U and Zn, together with LOI (loss on ignition) as a measure of their organic carbon content.

Orientation studies to determine the nature and extent of geochemical dispersion from several gold prospects and deposits into lake sediment were carried out by (McConnell and Davenport, 1989), and an evaluation of suitable commercially available methods, for the determination of gold in lake sediment at levels low enough to detect dispersion patterns, was made (Davenport, 1988). These studies demonstrated that measurable dispersion patterns of Au and other elements present in gold mineralization, such as Sb and As, are found in organic sediments from lakes near mineralization. Although the Au anomalies are subtle and low in absolute magnitude, a non-destructive, multi-element analytical method is available, which is capable of adequately measuring the Au abundances, and also those of several important pathfinder elements.

The techniques developed in the orientation studies have been applied successfully in determining the regional distribution of Au in Newfoundland, using the archive set of organic lake sediment samples (Davenport and Nolan, 1989). To date, data for Au and related elements for over half of insular Newfoundland have been released (Figure 1 and Table 1); and the results have stimulated and focused mineral exploration. This project is continuing, with archive samples from a further 20,000 km² from NTS sheets 1M, 1N and 12A (Figure 1) being analyzed, currently for release as three open files in 1990, and with the remainder of the areas to be covered between 1990 and 1992, funding permitting.

In addition to the analysis of the archive lake sediment samples by NAA for Au, As, Ba, Br, Ce, Cr, Cs, Eu, Hf, La, Na, Rb, Sb, Sc, Le, Ta, Tb, Th,W and Yb, these samples are being further analyzed at the geochemical laboratories of the Geological Survey Branch for Al, Be, Ca, Cd, Ga, K, Li, Mg, Nb, P, Sr, Ti, V, Y and Zr by ICP emission spectrometer. In Figure 2, the total-element suite of

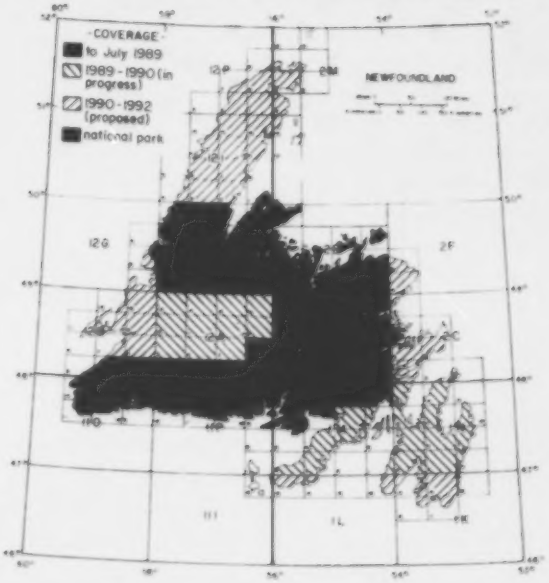

Figure 1. The re-analysis of archived lake sediment samples for gold and associated elements: areas completed by July 1989, areas from which samples are currently being analysed, and areas that remain to be done.

Table 1. List of open files of gold and associated elements in lake sediment for insular Newfoundland.

	NTS Area(s)	Open File	Date
1)	11O (all) 12H/9-11,15,16 12I/1	Nfld 1582	1987-09-24
2)	2E (all)	2E/563	1988-08-02
3)	2D (all)	2D/175	1988-11-01
4)	1M/5, 11-16	1M/276	1989-02-14
5)	11P (all)	11P/137	1989-03-29
6)	12H (all)	12H/1012	1989-06-06
7)	12A/1-4, 8 12B/1-	Nfld 1801	1989-07-11

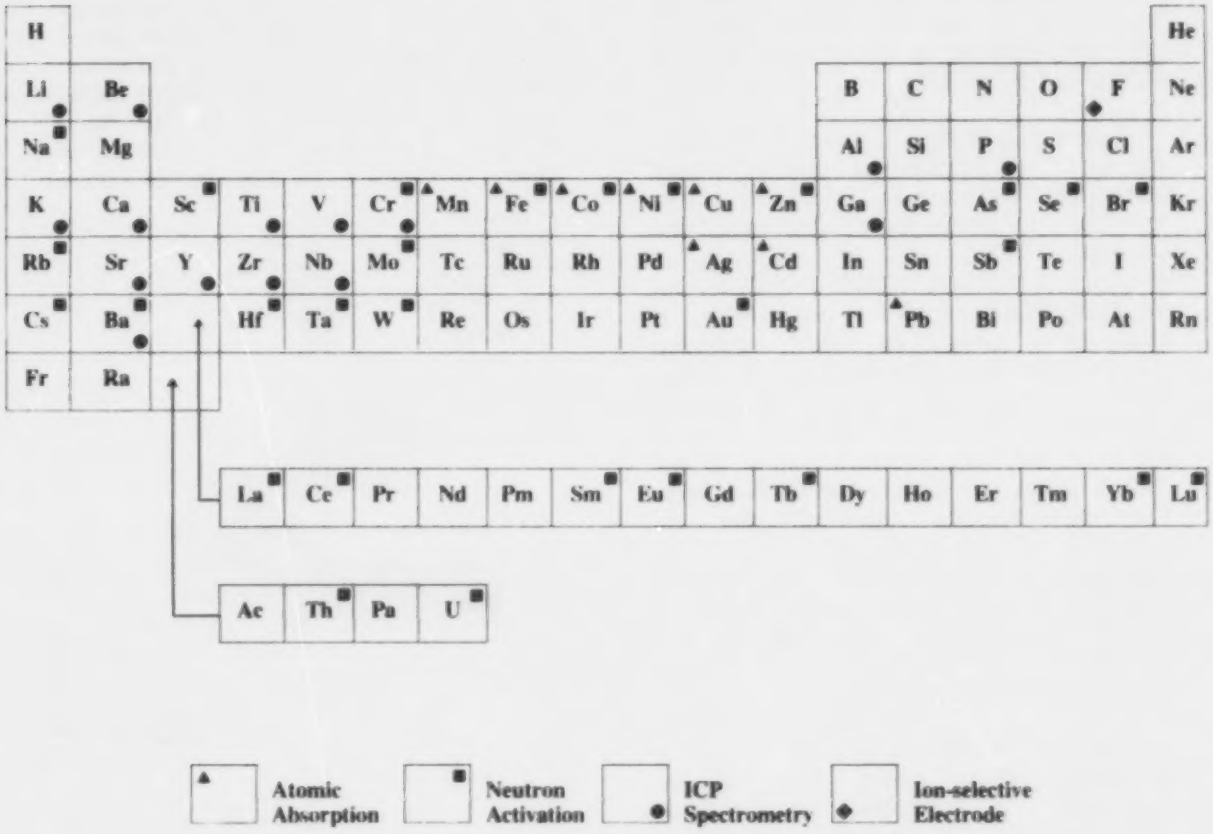

Figure 2. Elements currently being determined on regional lake sediment samples from Newfoundland.

48 elements is shown together with methods of analysis, with respect to the entire periodic table. This expanded suite will provide a comprehensive database to aid in exploration for most commodities, aid in general geological studies, and as well, provide much useful information for environmental studies on the geochemical background in Newfoundland.

The regional geochemical data set is becoming quite large, and to increase its value to users, micro-computer-based systems are being employed to manipulate and display the data to aid in their interpretation. Some of the techniques used, such as image analysis and geographic information systems, are described elsewhere (see Kilfoil *et al.*, *this volume*; Nolan, *this volume*).

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EVALUATING A NEW EXPLORATION METHODOLOGY: AN OVERBANK AND STREAM SEDIMENT SURVEY IN SOUTHERN NEWFOUNDLAND (NTS 1M)

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A field program was undertaken to determine the effectiveness of overbank sampling as a method of evaluating the mineral potential of an area. The method has proven its value in Norway, which has a similar climate, topography and glacial history to that of insular Newfoundland (Ottesen *et al.*, 1989). Regional lake sediment surveys are an excellent means of assessing the mineral potential, the metallogeny and regional geology of an area. However, the need for a supplementary survey method to complement the data from the lake sediment surveys has become apparent, for a variety of reasons. These include the need to obtain further detailed data from areas targeted by lake sediment surveys and in areas of inadequate lake density, and also to detect mineral occurrences, which may have an expression only in elements that are commonly immobile under surface conditions. Such elements include chromium, hafnium, niobium, tantalum, tin, titanium, platinum-group elements and zirconium (Brookins, 1988).

Overbank material, in contrast to the active stream sediment, is finer-grained sediment that is deposited outside of the normal stream or river bed, during extreme flood conditions. The material as a sampling medium is regarded as being more representative of the upstream catchment basin than is stream sediment. Rather than being derived from a restricted portion of the stream channel currently being eroded, the material represents a geochemical composite consisting of many successive flood deposits, separated in time.

To assess overbank material as a sampling medium, areas within the NTS 1M map sheet were selected for surveying (Figure 1) that have anomalous values of gold, antimony, arsenic, barium, lead, tungsten and zinc, in the regional lake sediment data (Davenport *et al.* 1989). Most of the areas chosen are along the coast, which offers the advantages of easy boat access to streams, and the highest likelihood of finding overbank material as the stream gradients are often lowest (hence least able to contain flood waters), near their mouths. In addition, the coastal strip is often an area of lower lake density and this survey would further complement the lake data. In the Bay d'Espoir area, several sites were also sampled from roads.

The study area is divided by the Hermitage Bay Fault into a region of predominantly volcanic, sedimentary and intrusive rocks of Hadrynian age to the southeast of the fault (Avalon Zone), and a region of predominantly clastic sedimentary and volcanic rocks northwest of the fault (Gander and Dunnage zones). The area includes five gold occurrences located in volcanic and sedimentary rocks of the Dunnage Zone.

Sampling methods included obtaining both an overbank sample and a stream sediment sample from each site, although sometimes both media were not available. During a three-week period, a two-person crew collected 71 stream sediment and 63 overbank samples. Twelve sites were sampled in duplicate. Overbank was recognized at most sites and was quickly obtained using a spade. The thickness of most deposits ranged from 0.2 to 0.4 m. To obtain sufficient stream sediment material (at least 100 g) for analysis, possibly including heavy minerals, sediment was wet sieved on-site to <300 µ.

Samples have been ovendried and will be analyzed during the fall and winter for a large suite of elements by instrumental neutron activation, inductively coupled plasma emission spectrophotometry (ICP) and atomic absorption spectrophotometry.

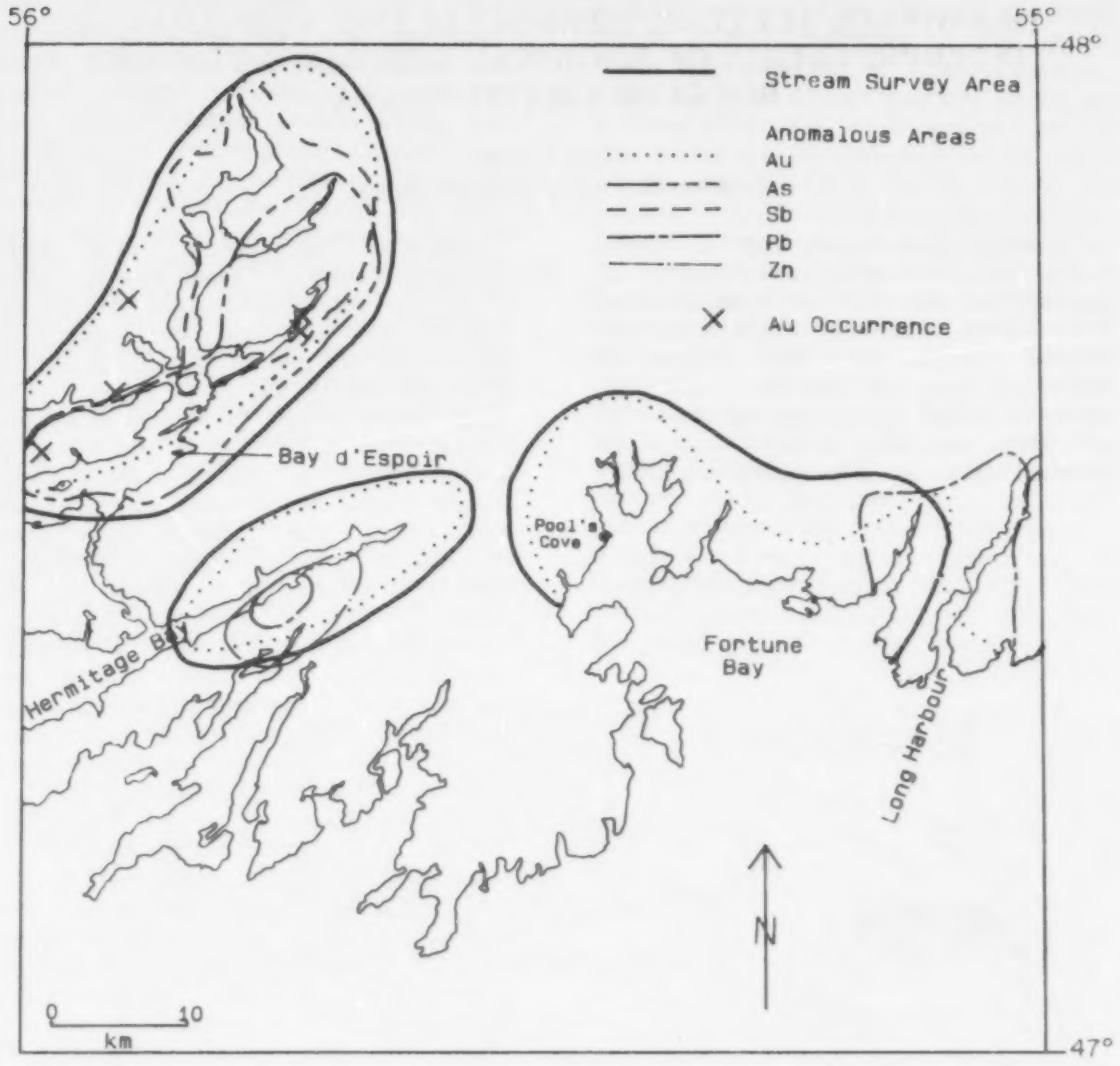

Figure 1. Location of overbank and stream sediment survey.

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GEOPHYSICAL CHARACTERIZATION OF THE WESTERN HERMITAGE FLEXURE, NEWFOUNDLAND: PRELIMINARY INTERPRETATION OF REGIONAL AEROMAGNETIC AND BOUGUER GRAVITY DATA

Gerry Kilfoil
Geochemistry and Geophysics Section

A series of geological maps at various scales, of the south coast region of Newfoundland (Figure 1) are being produced from digital, total-field aeromagnetic and Bouguer gravity data. This analysis is complementary to ongoing field and laboratory studies in the region by this author and others (*see* O'Brien and O'Brien, *this volume*; Dickson and O'Brien, *this volume*).

Figure 1. Location of study area.

Initial field-based geophysical studies, carried out during a two-week period in August, included reconnaissance magnetic and VLF-EM ground surveys to obtain geophysical signatures of mapped lithologies. To supplement proposed modelling studies of the regional data, representative rocks were collected for determination of density and magnetic susceptibility; the latter was also recorded at outcrops encountered along traverses.

Regional aeromagnetic data from Geological Survey of Canada surveys flown at 0.8-km (0.5-mile) spacing during the 1950's and 1960's have been acquired in digital form, and gridded to a 300-m interval to enable display and manipulation on an image analysis system (*see* Kilfoil *et al., this volume*). These IGRF-removed total-field grids have been plotted at 1:100,000 scale as colour contour maps. Subsequently, a series of colour-shaded relief images have been produced, at several orientations of directional filtering to enhance linear features that are clearly observable in the raw data. At present, the regional magnetic data for the south coast are being processed to obtain additional infor information by application of filters, which perform reduction to the magnetic pole, upward and downward continuation and apparent magnetic susceptibility mapping.

One of the principal objectives of the ongoing geophysical investigation is the identification of various features in the regional geophysical datasets that may express structural, emplacement and other relationships amongst various rock units. Emphasis is also being placed on the identification of structural linears and their possible relationship to mineralization of the region. Many of the above features have ready explanations; the origin of others are more enigmatic, and will require further detailed ground follow-up surveys, to form part of up-coming mapping and geophysical projects.

Through the use of directional filters, regional magnetic signatures are greatly enhanced. The images that result, such as that illuminated from the northeast (Figure 2), enhance structural information, particularly lineations oriented in the northeast and northwest directions. Important regional features, such as the curvilinear nature of the Hermitage Flexure, and distinct signature of the crust, south of the Bay d'Est and related

faults, are obvious from the data. The composite nature of both syn- and post-tectonic intrusions is also imaged, as are the Silurian sedimentary basins. The origin of north- oriented features evident with-in and adjacent to the Burgeo granite are less clear, although several are parallel to the major anomaly that marks the Dragon Bay fault zone. Many of these features apparently transect all earlier structures. A similarly filtered map of the Bouguer gravity field map highlights the great depth extent of the Silurian granite intrusions. In the offshore region, a broad positive gravity anomaly zone, which parallels the coast between the trace of the Bay d'Est and Hermitage Bay faults, may demarcate the northern edge of Avalon terrane rocks.

Geophysical profiles were established in the Peter Snout (11P/13) and La Poile (11O/9) areas. In the former area, basement/ cover relationships were investigated at the southeast margin of the Silurian, La Poile Group. Profiles established at this region should help establish the depth-to-basement, within the basin through magnetic modelling. The Bay d'Est Fault, which separates the La Poile Group and the Ordovican Bay du Nord Group, was bracketed by a profile. A geophysical profile was established within the Burgeo granite to investigate magnetic variation apparent on regional aeromagnetic maps. In the La Poile map area, Silurian volcanics and sediments have been distinguished from Cambro - Ordovician intrusives located on the north and south sides, respectively, of the Cinq Cerf Fault zone on the basis of magnetic and VLF-EM response. Farther to the east, a profile was surveyed across the Grand Bruit and Cinq Cerf fault zones. The traverse was extended northward from coastal exposures of Precambrian gneiss, across the thrust sheet bounded by the Grand Bruit and Cinq Cerf fault zones, into the La Poile Group.

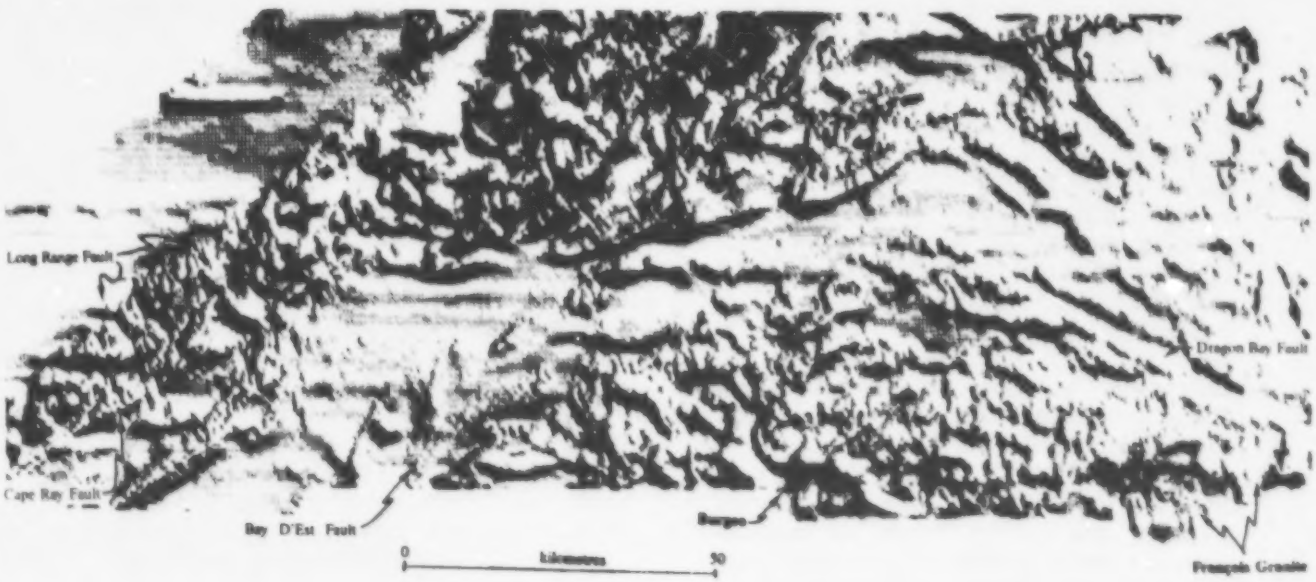

Figure 2: Shaded relief of regional aeromagnetic data for southwestern Newfoundland.

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This volume: Applications of a PC-based image enhancement and analysis software package to geophysical and geochemical data.

O'Brien B. and O'Brien, S.J.
This volume: A new map of the region south of the Bay d'Est Fault (parts of 11O/9,16; and 11P/12,13), southwest Newfoundland.

APPLICATIONS OF A PC-BASED IMAGE-ENHANCEMENT AND ANALYSIS SOFTWARE PACKAGE TO GEOPHYSICAL AND GEOCHEMICAL DATA

Gerry Kilfoil, Larry Nolan and Bill Jones
Geochemistry and Geophysics Section

INTRODUCTION

An image analysis and display software package has been acquired, by the Geochemistry and Geophysics Section, and installed on a PC to assist in the preparation and presentation of regional geochemical and geophysical datasets. This has been done because the vast amounts of data represented, have proven unwieldy to processing and display by alternative techniques. This acquisition represents the first step toward an overall plan of combining an image analysis system with a Geographic Information System (GIS), to expediate the assimilation and integration of the many and varied types of geoscientific information (see Nolan, *this volume*).

The display system enables three image channels of 512 by 512 pixels to be displayed in each of the three colour guns, red, green, and blue, which additively combine to produce a broad range of colour possibilities in a single image. In addition, up to 8 monochrome bitplanes can be enabled to permit masking of or overlay of additional information on the image, such as topographic or geological outlines. The sizes of the raster databases are restricted only by storage capacity; virtually any number of corresponding raster images and accessory bitplane overlays (stored as bitmaps) may be combined into a single file. Thus, many different types of spatial data for a single region may be stored together.

Aside from the basic display capabilities of the PCI EASI-Pace system, the package has many image pixel and bitplane manipulation features. These include geometric correction and interpolation of images (useful for resampling remotely sensed data images), application of directional and edge enhancing filters, principal component analysis, unsupervised image classification or supervised classification, based on training areas, thresholding images to bitplanes, bitplane to bitplane logical operations, and output to various hardcopy devices. In addition, routines were written outside of the EASI-Pace environment to import digitized reference data (such as sample locations, topographic outlines or geological boundaries) directly into EASI-Pace raster files as bitmaps.

CURRENT APPLICATIONS

Upon its acquisition in January 1989, Version 3.2 of the EASI-Pace software was installed on a 80286-based microcomputer with 40 megabytes (Mb) of hard disk space, a 1.2 Mb, 5.25 inch and a 1.44 Mb, 3.5 inch floppy disk drive. A choice of hardware devices between the Tektronix 4696 colour printer and 24-pin Epson printer allow colour hard copy of images and printed text output, respectively. Version 4.1 of the software, which arrived in March, brought about a complete revamping of the database structure. With this new version, portions of data files may be deleted, appended or updated without affecting the integrety of the information contained in the remainder of the file. Also, the requirement of generating intermediate files was eliminated by enabling the EASI-Pace raster image files to be written directly, exterior to the EASI-Pace software environment. Thus, the series of programs designed to convert gridded data points to raster images was re-written to take advantage of the new storage structure. This seemingly minor change greatly enhanced the efficiency of the transfer of data from the raw collected form to the final format of EASI-Pace image display.

The transfer of the EASI-Pace software, in August, to a 80386-based, 25 MHz microcomputer with 310 Mb of hard disk space and a 40 Mb backup tape drive, further

increased speed of operations and streamlined the processing stage by eliminating the bottlenecks inherent in limited disk space and slow data input/output. Through batch programming, the increased space allows much of the expensive computer processing phase to be executed overnight, without the intervention of an operator. A digitizing tablet was purchased to further assist in digital data input.

DATA TYPES AND SOURCES

With the exception of satellite imagery, digital geoscientific data is generally, not in a raster image form. Geophysical and geochemical data are usually collected at irregularly spaced sample locations determined by topography, as in lake sediment geochemistry, or at relatively regular, closely spaced intervals along irregular, more widely spaced lines, as in aeromagnetic flight lines. As a consequence, most data must be processed with interpolating routines to produce representative values in a uniform grid or raster image. Two routines from Geosoft's Mapping Package, which enable random and bi-directional interpolation, respectively, have been used almost exclusively for the production of raster input to the image analysis system. Therefore, a series of programs have been written to convert output grids in Geosoft format to input raster images in EASI-Pace format. A significant effort has been expended in exploring the options of random gridding and their effects on images resulting from application to regional lake sediment geochemistry data. The choice of parameters is largely case dependent; a thorough understanding of the precision and limitations (such as detection limits, etc.) of the input data is imperative both in selecting the gridding parameters and interpreting the images that result.

Any type of information that can be quantified as describing a parameter that varies from site to site may be converted to raster information for input to an image analysis and display system. The large volumes of digital information represented by regional geophysical and geochemical survey data are particularly amenable to input to a raster-based database and display, via an image analysis system. The larger datasets, such as Landsat or aeromagnetic data, are downloaded from 0.5 inch, 1600 BPI, 9-track digital tapes through a tape drive connected to the HP-9000 mini-computer, then downloaded once again through a link to a PC, before further processing by routines for gridding and conversion to raster images. Other data types are often resident on diskette and, therefore, are in a form readily accessible by PC-based processing software. In instances, some pre-processing such as gridding of large randomly dispersed datasets is done using software packages resident on the HP-9000 mini-computer. To date, most of the work completed has employed individual element, concentration data from regional lake sediment surveys, total-field aeromagnetic flight-line data and both regional and detailed gravity survey data combined with topographical and geological information. In specific study areas (Figure 1), remotely sensed Landsat and airborne radiometric survey data are also being used in developing models for resource evaluation.

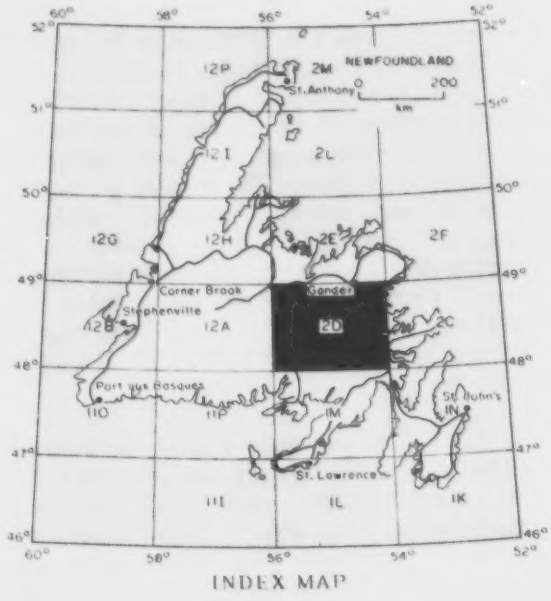

Figure 1. Location of study sites.

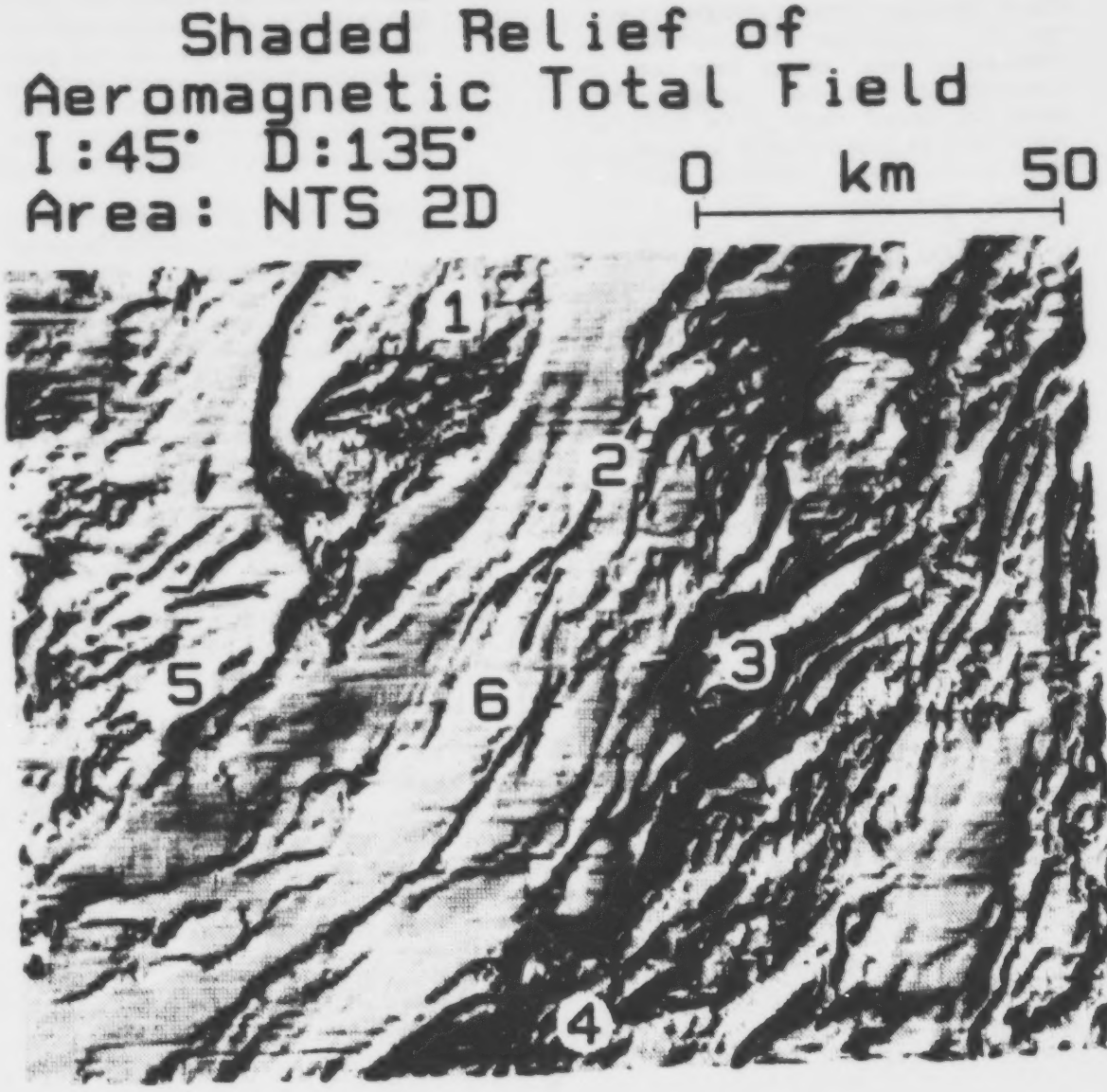

Figure 2. Shaded relief of regional aeromagnetic data for NTS 2D, Gander Lake, Newfoundland, showing the features marked: 1 - Mount Peyton intrusion; 2 - Ultramafics of the GRUB line; 3 - Maccles Lake granite; 4 - northern parts of the Ackley Granite; 5 - Great Bend ophiolite on the eastern margins of the Tim Horton Complex; 6 - Middle Ridge Granite. Note also the pre- dominance throughout the region of magnetically defined structural trends in the NE directions and more subtley in the NW direction. False sun illumination is incident from the NW and inclined at 45 degrees to the horizon.

Figure 2 shows an image of total field aeromagnetic data for NTS/2D, directionally filtered from the northwest direction. Options that allow production of monochrome or colour-shaded relief images have been incorporated into the data transfer routines, which link Geosoft output to the EASI-Pace raster input. To produce colour and images, a single-gridded data parameter, such as uranium concentration or Bouguer anomaly value, is directionally filtered and converted to three output channels, which combine to a full-colour display. Aside from the filtering, such processing effectively extends the dynamic range of the image and allows the interpreter to detect subtleties that would not be otherwise as readily identifiable in a single channel display. Extending the dynamic range of a dataset also creates a smoother and more appealing image. An additional option has been incorporated that enables the production of shaded relief (or unshaded) colour stepped-surface images, which display regional geochemical data in a more effective manner. The parameters controlling directional filtering (false sun illumination) and the choice of output image type are controlled by the operator from a simple command file.

Projects that are currently underway or scheduled for the near future on the image analysis system include:

i) Creation of a province-wide database of regional total field magnetic and Bouguer gravity data for Newfoundland and Labrador, from which any subarea may be readily extracted to complement localised study.

ii) Processing of other regional geophysical datasets, such as various Geological Survey of Canada radiometric surveys and the high resolution total-field aeromagnetic/gradiometric survey extending from Notre Dame Bay to Victoria Lake. In addition, both of these datasets have supplementary VLF-EM survey data.

iii) Creation of a regional lake sediment geochemical database of Newfoundland Labrador consisting of interpolated raster grids and colour shaded stepped-surface images stored in PCI data formats. Detailed subsets of these data files can be processed to investigate anomalous regions.

iv) Evaluation and incorporation of Geosoft's Magmap routines into the processing stream. These series of programs are designed to efficiently apply filters in the wavenumber domain to enable such operations as upward/downward continuation of gravity and magnetic data; reduction to the pole and susceptibility mapping of magnetic data.

v) Investigating and establishing links to the GIS that would allow resource evaluations based on modelled combinations of various geoscientific parameters.

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GEOGRAPHIC INFORMATION SYSTEM (GIS): A TOOL FOR SPATIAL ANALYSIS OF DIGITAL GEOSCIENCE DATASETS

W.L. Nolan
Geochemistry and Geophysics Section

INTRODUCTION

This project, for the spatial analysis and integration of geoscience data, began in 1988 as a new initiative by the Geochemistry and Geophysics Section to assist geologists overlay, integrate and manipulate multiple layers of digital geoscience datasets of varying scales and complexities. The project consists of three distinct phases, which are being implemented over a three-year period.

Phase I-1988: Phase 1 entails the installation of the PCI EASI-Pace image analysis software on a micro-computer. This system has been in use since January 1989, produces shaded relief and other enhanced geophysical and geochemical images. Demonstrations of the systems capabilities were held during March and April for geologists of the Newfoundland Department of Mines and Energy, as well as for local geologists.

Phase II-1989: A powerful 80386-based 25 mhz micro-computer having 310 mb of disk storage and tape backup capability was acquired and dedicated as the image/spatial analysis workstation. A Tydac SPANS spatial analysis system was acquired in August for the integration of geographic, geological, geochemical and geophysical data sets into a common geographically referenced database, thereby permitting a comprehensive quantitative data analysis.

Phase III-1990: The purchase of a raster-based colour plotter is anticipated in the 1990/91 fiscal year to allow for the production of colour maps and images, up to 36 by 48 inches (91 by 122 cm) in size from the image and spatial analysis systems at varying scales.

OBJECTIVES UNDER PHASE II

The initial installation of the GIS, and user training on system operation, has been completed and work is in progress to establish methods for data input and for standardizing feature definitions of geological base maps for Newfoundland and Labrador. Once data formats have been set, a user manual will be compiled outlining to geoscientists procedures to follow for data input into the GIS, thus keeping digital data belonging to different projects compatible with a common provincial data base.

Along with the extensive geoscience databases held by the Geological Survey Branch, there are many other databases that may be of interest to geologists. Other sources of digital data are available from government departments (both federal and provincial) and private companies. A few of which are being investigated for geological purposes include:

- digital topographic data - nineteen map sheets of the 1:250,000 topographic map series covering all of the island have been scanned and stored as vector line files in ASCII format,

- digital hydrographic data - watersheds, lakes and streams for the Province of Newfoundland and Labrador are available from Environment Canada,

- digital forest inventory - forest cover information containing up-to-date, secondary and access road locations has been completed for about a quarter of the island by the Department of Forestry, and

- the Canada Land Inventory - environment Canada has several databases of agriculture, land use, ecological land inventory and many others.

The remainder of this year will be spent gathering and organizing digital databases that are relevant to both geology and mineral exploration for integrated spatial analysis of the geochemical datasets. The combination of digital, topographic, geochemical (up to 50 elements), aeromagnetic and gravity data with a digitized, geological base map will provide a true test of the powerful overlaying, modelling and indexing capabilities of the SPANS GIS on a multi-layered data set.

QUATERNARY GEOLOGY

QUATERNARY GEOLOGY OF THE HUMBER RIVER BASIN

Martin Batterson
Terrain Sciences Section

INTRODUCTION

The Humber River basin occupies a lowland area between several potential Wisconsinan ice-centres, which lie to the north of the basin in the Long Range Mountains and to the southeast and east in the Topsail Hills (Figure 1). The basin may therefore, at different times, have been affected by ice from these sources, as well as by marine incursion into the Deer Lake area. Hence, the potential for a stratigraphic record of the Wisconsinan (and possibly earlier?) exists in the Humber basin.

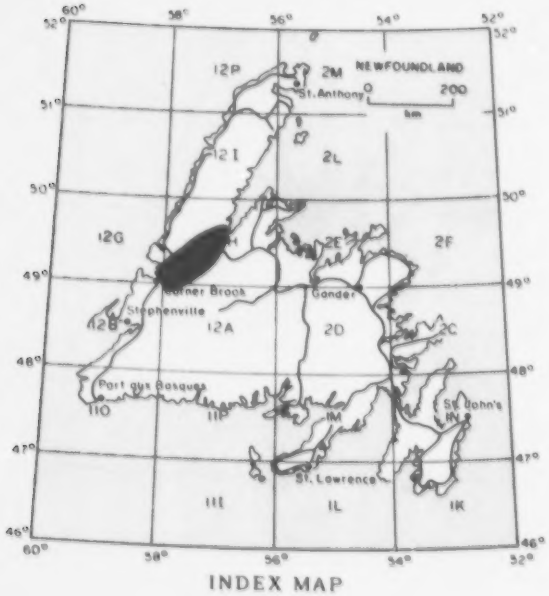

Figure 1. Location of study area

Previous work in the area has documented several major ice-flow directions (Vanderveer, 1982; Rogerson, 1979; Lundqvist, 1965), but the sequence of events is rather speculative and commonly inconsistent with each other. Therefore, no clear picture of the glacial history of the Humber River basin exists.

The initial focus for this current study was to undertake a reconnaissance survey of the area, to collect and compile ice-flow direction indicator data, and to identify and briefly describe the Quaternary sedimentary sections.

ICE-FLOW DATA

Evidence from glacial erosional features in the central and southern part of the basin suggests a dominant westward ice flow from a source in the Topsail Hills. This is supported by clast analysis from glacial sediments that contain distinctive Topsail intrusive suite rocks. However, in some places, evidence for a southwestward flow was also found in striae; but this flow was restricted to the basin. In the northern and at the eastern margin of the basin on Birchy Ridge, southward-trending striae were observed. The origin of this flow and its temporal relationship to events elsewhere in the basin is unclear.

QUATERNARY SEDIMENT

Much of the Humber River basin is covered by an extensive and variably thick sediment overburden. The overburden is mainly derived from the soft Carboniferous bedrock that comprises the basin. Over the Long Range Mountains and Topsail Hills to the west and east of the basin, respectively, the overburden cover is generally thin and discontinuous.

Within the basin, sections of diamictons, glaciofluvial sands and gravel and glaciolacustrine - marine silts and clays record the glacial and deglacial history. Most can be reconciled with either ice-flow indicators or paleo-drainage channels. However, of interest are high-level deltas (140 m.a.s.l.), in the Pasadena and Grand Lake areas, which suggest the existence of a lake occupying the Grand Lake - Sandy Lake - Deer Lake - Humber River basin, during the late Wisconsinan.

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BEDROCK AGGREGATE ASSESSMENT

Dan Bragg
Terrain Sciences Section

The 1989 field season was divided into two programs. The first was an evaluation of the aggregate potential of bedrock quarries and road-cuts between Gander and Grand Falls (Figure 1). This assessment was carried out to determine the quality and quantity of bedrock for local use. The second was a reconnaissance-type evaluation of the south coast of Newfoundland (Bay d'Espoir - Burgeo area) (Figure 1). This assessment was undertaken to determine the quality and quantity of bedrock available for export to international markets.

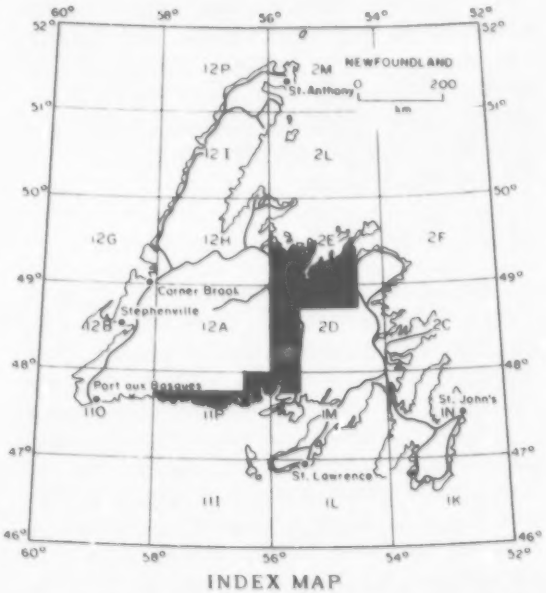

Fig. 1 Field Areas - Bedrock Aggregate Assessment Project - 1989

For the first six weeks of the field season, work centered in the Gander and Grand Falls areas, whereas the last six weeks of the field season it focussed on the south coast of Newfoundland. Field work consisted of traverses along the highway and side roads, and visiting all the rock quarries in the vicinity. Helicopter traverses were also completed along the south coast.

The field investigations for each site consisted of determining, when and where possible, the ownership and use of each quarry. Rock types, overburden, weathering, geological structures, mineralization, veining and alterations were also noted during site investigations.

During the field investigations, rock samples that weighed from 2 to 45 kg were taken for laboratory testing. This testing includes $MgSO_4$ soundness test, Los Angeles Abrasion test, petrographic analysis and numbering.

A total of 252 sites were visited and 210 samples taken. Further sites having potential for exportable aggregate were discovered and data on these and other sites should be available by the end of 1989 or early 1990.

ACKNOWLEDGMENTS

The author thanks Mr. Jeff Cluett and Mr. Lloyd St. Croix for their capable assistance during the first and second half of the field season, respectively.

QUATERNARY GEOLOGY OF THE KING'S POINT MAP SHEET (NTS 12H/9)

David Liverman and Sharon Scott
Terrain Sciences Section

INTRODUCTION

This project was initiated to better define the Quaternary geological history of the area, which in itself may help improve the efficiency and effectiveness of drift exploration. Reconnaissance work in 1988 indicated that the King's Point map area has a relatively thick drift-cover and a complex ice-flow history. The objectives for the 1989 field season were to ground-check aerial-photograph interpretations, to supplement existing ice-flow data, and to undertake a programme of detailed sampling of surficial sediment.

BEDROCK GEOLOGY

The bedrock of the King's Point map region can be described simply, by a division into four areas.

1) Humber Zone rocks of the Fleur de Lys Supergroup and East Pond Complex are found west of the Dorset Trail. The East Pond Complex consists mainly of metaconglomerate, psammitic and semipelitic schist, and amphibolite, with lesser amounts of migmatite and banded gneiss (Hibbard, 1983, 1989). The Fleur de Lys Supergroup consists of psammitic and semipelitic schists. The Baie Verte Lineament forms the eastern boundary of the Humber Zone, and runs southwest-northeast, close to the Dorset Trail.

2) East of the Baie Verte Lineament, Dunnage Zone rocks of the Baie Verte Supergroup and Mic Mac Lake Group are exposed. The Baie Verte Supergroup consists of ultramafics, gabbroic intrusives, diabase dykes, pillow lavas, flow lavas, and pyroclastics. The younger Mic Mac Lake group consists of sub-aerial silicic volcanic and pyroclastic rocks, with minor sandstone and conglomerate (Hibbard, 1983, 1989).

3) The central part of the map area is dominated by two major intrusions; the Burlington granodiorite, and an unnamed quartz-feldspar porphyry (Hibbard, 1983, 1989).

4) The Green Bay Fault separates the above rocks from rocks of the Catchers Pond, Western Arm, Lushs Bight, and Springdale groups, which form the bedrock of the southeast of the map sheet. The Catchers Pond Group is dominated by acidic volcanic rocks, and the Western Arm Group contains pillow lavas, tuff, agglomerate and breccia. The Lushs Bight Group contains pillow basalt, breccia, tuff, chert, diabase dykes and gabbro. The Springdale Group consists of conglomerate, sandstone and mudstone (Dean, 1977; Kean, 1977).

PREVIOUS WORK

Earlier work is summarized by Hibbard (1983). Lundquist (1965) examined striae in the area and suggested that major ice flow was from the southwest to northeast over the peninsula. He thought that as deglaciation progressed, local topography became increasingly important and gave rise to considerable variation in flow direction. The area was mapped on a reconnaissance level at 1:50,000 by Grant (1986), mainly by aerial-photograph interpretation, but with some ground checking. Further work by Liverman and St. Croix (1989 a, b) suggested that ice flow was much more complex than previously thought.

ICE FLOW

Interpretation of ice-flow history over the area is based mainly on striae, as larger scale oriented landforms are rare. Two major phases of ice flow are documented. Striae indicating a northward flow are commonly

found preserved in the lee of a later eastward flow. Each of these events show some variation. The early northward flow varies from northwestward in the western and northwestern part, to northeastward in the area north of Springdale and east of King's Point. In this same area, the later flow is southeastward. Consideration of well-oriented bimodal or unimodal clast orientation distributions in diamictons suggests the dominant sediment-moving ice flow in the area was generally eastward. Exception to this occurs only in the northwest where fabrics suggest a northerly flow.

SURFICIAL SEDIMENT

The sediment thickness ranges from a thin veneer over bedrock to greater than 50 m. Five major units are tentatively defined.

1) The dominant sediment type is glacigenic diamicton, covering approximately 80 percent of the area. It is thickest over the south, with mainly a veneer found to the north. It shows a wide range of clasts sizes, and commonly contains lenses and laminae of sorted sediment. It is likely dominantly deposited by basal meltout.

2) Poorly sorted gravels are frequently observed in the map area as ridges, mounds or with no distinct topographic expression. In poor exposures, these might be confused with till, but have few fines in the matrix. They are interpreted as gravel deposited in an ice-contact environment as eskers or kames.

3) Well-sorted coarse gravels are found south of Flatwater Pond, in the north of the map sheet, along Black Brook to the south of the area, and west of Springdale. These are interpreted to be pro-glacial outwash deposits.

4) The area has undergone uplift following deglaciation due to isostatic rebound. The highest sea level recorded is 75 m above the modern sea level. Below this altitude, in coastal areas, a variety of sediments have been deposited, affected by this raised sea level. East of Springdale, exposures of resistant clay and silt having common coarse clasts are interpreted as being deposited in an ice-distal glaciomarine environment. East of King's Point, well-exposed sections show poorly sorted gravel and diamicton, interpreted as representing deposition in ice-proximal glaciomarine/ prodelta conditions. Spectacular exposures through up to 50 m of well-sorted gravels deposited in deltas are seen in Springdale, King's Point and Rattling Brook. Marine terraces are found along the coast at altitudes ranging from 5 to 20 m above sea level, and consist of moderately sorted gravel.

5) Bog is observed sporadically throughout the area. Minor units include colluvium, found at the base of steep slopes. There is evidence to suggest that a higher stand of Micmac Lake is represented by poorly defined beaches, 2 to 5 m above present lake level, along the western margin; and well-sorted sands with common large clasts found 10 m above the modern lake level at its southern end.

IMPLICATIONS FOR DRIFT EXPLORATION

The ice-flow history detailed above suggests that sediment dispersal should be dominated by the later eastward flow. It is possible that reworking of till deposited by earlier ice movement and forming north-trending dispersal trains might result in dilution of such dispersal. Diamicton deposited as basal meltout till should represent an ideal sampling medium for tracing of dispersal.

Careful examination of surficial sediment is required to distinguish diamicton from ice-contact gravels, which would show dispersal patterns unrelated to ice flow.

Geochemical results from sampling of coastal areas below 75 m above sea level must be interpreted with care due to reworking of glacigenic sediment by marine processes. Similar caution should be exercised in the vicinity of Micmac Lake.

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SURFICIAL GEOLOGY MAP OF INSULAR NEWFOUNDLAND

David Liverman and David Taylor
Terrain Sciences Section

OBJECTIVE

Integrated surficial geology maps do not exist for the island of Newfoundland. Examination of existing map coverage suggests that, with some additional aerial-photograph interpretation, compilation of a 1:500,000 scale map would be possible. Such a map is considered to be important because:

1) it would enable the Geological Survey Branch to very accurately evaluate the quality and extent of existing coverage,

2) it would be used as a tool for planning future mapping,

3) the 1:500,000 scale allows recognition of broad patterns of sediment distribution, which could aid in the interpretation of glacial history of the island, and

4) a compiled map allows presentation and summary of much work at present in limited distribution.

LEGEND

The legend adopted was of necessity, simple. The objective is to produce a descriptive map of the surficial sediment. A legend was designed to accommodate all existing mapping with minimum re-interpretation. Thus, a simple breakdown based initially on grain-size distribution was chosen. This was elaborated by sub-division using geomorphology, and sediment thickness. In complex areas, or in areas with mixtures of sediment type, only the dominant sediment type was displayed by the legend. Genetic interpretation was considered unimportant in designating units, although such an interpretation is attached to the legend.

SOURCES

A full list of sources will be appended to the first draft, but most of the map has been compiled from existing mapping undertaken by the Geological Survey Branch of the Newfoundland Department of Mines and Energy, and the Geological Survey of Canada. Geological Survey Branch mapping is of two types; i) the bulk of available mapping consists of reconnaissance aerial-photograph interpretation, with the primary objective of locating aggregates. A terrain classification legend was used in these maps, enabling easy adaptation into that used for the compiled map, and, ii) more detailed maps, based on aerial-photograph interpretation, but with substantial field checking, cover a small part of the island.

Geological Survey of Canada mapping mostly uses a legend that is in part interpretive, but was adaptable to the system adopted with some additional aerial-photographic interpretation. In areas of dual coverage, reliance was placed on Geological Survey Branch mapping, as the original aerial-photograph interpretation and the interpreters were usually available for consultation.

After collection of available mapping, large areas remained uncovered. Department of Mines and Energy geologists co-operated to map these areas by aerial-photograph interpretation. Martin Batterson and Dave Proudfoot covered large areas of NTS sheet 2D; Dave Liverman covered parts of 12A, 2D, 11P and 1M; and Lloyd St. Croix filled some gaps on 2E and 2F.

METHODS

Existing maps are mainly at 1:50,000 and 1:250,000 scale. These were roughly coloured according to the final legend, disregarding any

unit smaller than 1 by 1 km. In the case of terrain classification legends, the dominant terrain type was used where a unit was composite. 1:50,000 maps were then transferred to 1:250,000 bases, and boundaries between map areas checked, in some cases with the aid of further aerial-photograph interpretation. 1:250,000 maps were coloured, and boundaries checked prior to transference to the 1:500,000 base.

RESULTS

The first draft of the map will be presented for review and comments by interested parties, and revised before preparation of a final copy. Users of this map should be aware of a number of limitations:

1) the quality and accuracy of the map is dependent on the original larger scale mapping. In most cases, and in particular the areas mapped specifically for this project, there has been little to no ground checking of the aerial-photographic interpretation. Experience has shown that such interpretation is fairly accurate, but ground checking can yield extensive modification of up to 50 percent of the interpretation,

2) many boundaries are gradational, and subject to the judgement of the individual interpreters. In compilation, differences in interpretation were obvious at boundaries between mapping by different authors. Such differences were generally minor, but result in the unit fitting into different categories of the legend adopted for the compilation map. For example, a unit might be mapped as till veneer having areas of vegetated rock by one author; and dominantly vegetated rock having patches of till veneer by another. Major differences in interpretation were rarely encountered. To accommodate such examples without resorting to re-examination of aerial photographs, boundaries have been placed that may not reflect actual differences in surficial sediment,

3) the scale of the map results in the omission of many small deposits but of major importance, economically and otherwise. For example, many ice- contact sand and gravel deposits are too small to show on a 1:500,000 scale map but are important sources of aggregate. Similarly, many small areas of bog are found throughout the island, but usually will not form a large enough area to be displayed, and

4) the glacial and post-glacial sedimentary environments are complex, and result in a complicated distribution of surficial sediment, having considerable lateral and vertical variation over short distances. Any surficial mapping results in simplification of this distribution, but this is particularly marked on a small scale map, such as that presented here. Terrain classification legends can accommodate units composed of a mixture of terrain types, but the decision to only show the dominant sediment type for a given area on the compiled map may mislead users. It must be emphasized that each map unit of the compiled map shows only the dominant sediment type found in the area, with associated sediment types not represented.

Given these limitations it is hoped that the map will be useful on a broad scale and will point users to sources of more detailed mapping, if more appropriate for their requirements.

FUTURE PLANS

1) Following review of the first draft, a final coloured map will be produced as soon as possible.

2) This map will be followed by further similar scale maps of geomorphology, and ice-flow indicators.

3) In the course of compilation, 1:250,000 maps were produced as an intermediate stage, and it is planned to issue these as open-file releases in areas where no map of comparable scale exists.

GLACIAL LANDFORM INVESTIGATIONS IN SOUTHEAST - CENTRAL NEWFOUNDLAND

D.N. Proudfoot and S. Vardy
Terrain Sciences Section

A detailed investigation of select glacigenic ridges in southeast - central Newfoundland (NTS 2D/6, 11 and 12) was carried out, as a follow-up to surficial mapping and completed in 1988 (Proudfoot *et al.*, 1988, 1989). In this area, the origin of these ridges is a key factor in the interpretation of glacier dynamics and may provide clues to sediment transport distances, particularly because they contain most of the glacigenic sediment that is not covered by bog. The focus of the 1989 field season was to obtain additional data on crescentic to sinuous ridges. Four sites were selected for detailed study using a skidder-mounted backhoe.

BACKGROUND

All sites are underlain by similar metasedimentary rocks of the Gander and Baie d'Espoir groups, hence differences in bedrock character are not likely to be a major consideration. Within the area of thickest, unconsolidated sediment cover, four types of ridges have been identified. They are: 1) straight oriented ridges (crag-and-tail and flutes), 2) crescentic to sinuous ridges, 3) irregular oriented ridges, and 4) hummocks.

The genetic interpretation of straight oriented ridges and hummocks has been discussed previously (Proudfoot *et al.*, 1989). The genesis of crescentic to sinuous ridges is more problematic so more data was collected on them, in 1989. Unfortunately, there is no road access to these irregular oriented ridges and therefore they were not studied.

RESULTS

The first site was a 10-m-high, crescentic to sinuous ridge on the southeast side of the microwave tower that is located about 4 km south of Berry Hill Pond. There is striation evidence in this area for only a southward ice flow. Three trenches, 3- to 3.5-m deep, were excavated parallel to ice flow along each of two transects across the ridge. The crest of the ridge, which is oriented east-west, contains massive, compact, sandy diamicton (till-like) having gravelly lenses. The flanks of the ridge are composed of diamicton that contains silty, sandy laminations, some of which are normally graded. Of the 6 pebble fabrics measured (1 in each trench), one site on the down-ice side has a strong fabric parallel to ice flow and one site on the ridge crest has a strong fabric transverse to the ice flow. These preferred orientations are likely the result of deposition at the base of a glacier (Dowdeswell and Sharp, 1986). The slope-parallel orientation of laminations and lenses in most of the laminated sediment, and the weak pebble fabrics within the diamiction that contains them, are interpreted to be the result of debris flows on the slopes of the ridge. The geometry of the ridges, their transverse orientation with respect to ice flow and the two strong fabrics are interpreted to be due to ice pushing within ice-marginal joints or at an ice margin (Bouchard, 1989; Kruger, 1985; Cowan, 1968).

Two trenches were made in the slopes of each of 2 crescentic ridges, north of Little Gander Pond along the boundary between NTS 2D/6 and 11. These ridges are about 1.5-km long, 5- to 8-m high and are convex toward the southwest. Ice flow, as interpreted from striations in the area, was southward (160°) and later northeastward (060°). The dominant sediment within the ridges is massive, moderately compact, silty sandy to sandy diamicton. In one ridge, there are sand and gravel beds and lenses and a steeply dipping (60°) sand dyke. The pebble fabric on both flanks of this ridge is strong and oriented northeastward (073° and 038°), which is in the same general direction as the latest ice flow in the area. The ridge geometry, the strength of these fabrics and their orientation

are interpreted to be the result of subglacial deposition (Bouchard, 1989; Kruger, 1985; Cowan, 1968). In the other ridge, the diamicton contains synformally deformed sand lenses beneath some cobbles and an underformed sandy gravel bed at 3 m depth, which is glaciofluvial in origin. These lenses and beds and the weak diamicton fabrics from the ridge are interpreted to be the result of resedimentation processes unrelated to basal ice flow (Downdeswell and Sharp, 1986; Lawson, 1979), however, the ridge is interpreted to have formed in the same way as the crescentic ridge discussed above.

IMPLICATIONS TO DRIFT EXPLORATION

Most drift sampling is carried out where there in no bog cover. In the study area, glacigenic ridges contain most of the unconsolidated sediment that is not covered by bog and in many places it is likely thick enough to prevent the development of hydromorphic anomalies related to underlying bedrock. An understanding of ridge genesis is therefore critical to the development of effective drift prospecting strategies.

It is suggested that crescentic to sinuous ridges contain material derived from the base of the glacier that formed them. Much of the near-surface sediment (less that 3 m) in the ridges does not have the characteristics of basal till but because it is interpreted to be mainly the result of slumping of basally derived material, it is therefore, likely, a relatively good sampling medium. Compositional banding (Bouchard, 1989) of poorly stored diamicton layers and better sorted sandy and gravelly layers are common, but no compositional differences have been observed in the pebble lithology between layers.

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GRANULAR AGGREGATES IN CENTRAL NEWFOUNDLAND

M.J. Ricketts and J. McGrath
Terrain Sciences Section

Field season activities, in 1989, marked the beginning of a regional aggregate-resource mapping program of granular aggregates for the island of Newfoundland. The program's objectives are to locate, map and sample all sand, gravel and sandy till deposits, which amongst others, have potential use in concrete, asphalt and road construction. Work has been concentrated in central Newfoundland on NTS 1:50,000-scale map sheets 2D/15, 2E/2 and 2E/7 (Figure 1). Field work was conducted in a manner similar to the Inventory of Aggregate Resource Program (Kirby *et al.*, 1983), which sampled a 6-km-wide corridor along transportation routes and an 8- to 50-km radius around populated areas in Newfoundland and Labrador.

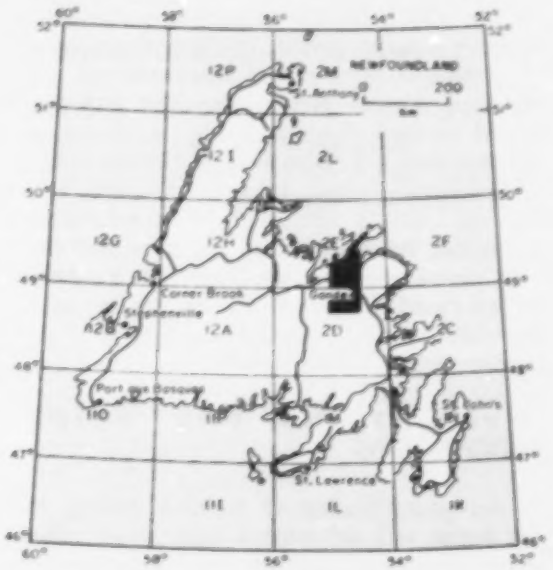

Figure 1. Location of study area

Several deposits were mapped and sampled in the study area. These include deposits at Southwest Brook, Careless Brook, Hunts Cove and Hunts Pond on map sheet 2D/15, Salmon River, Little Salmon Pond, Gander River on map sheet 2E/2 and Burnt Lake, Birchy Bay and Loon Bay on 2E/7.

Petrographic numbers, determined from analysis of the 16- to 32-mm pebble fraction, indicate material in the map area has poor petrographic qualities having numbers generally greater than 200. One exception to this is the deposit near Salmon River where petrographic numbers are as low as 100. Grain-size analyses are incomplete but will be available later this year. Los Angeles Abrasion tests will be conducted to determine resistance to abrasion, and soundness tests (Canadian Standards Association, 1973) will also be conducted to determine aggregate quality for use in concrete and asphalt.

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ICE FLOW IN NORTH-CENTRAL NEWFOUNDLAND

Lloyd St. Croix and Dave Taylor
Terrain Sciences Section

INTROUDCTION AND OBJECTIVE

The north-central part of Newfoundland is an area of considerable mineral exploration interest, especially for gold and base metals. A thorough understanding of the area's recent glacial history in terms of ice-striae characteristics could help to enhance the efficiency and effectiveness of drift exploration.

The objective of the project was to compile reconnaissance level maps of glacial striae, at a 1:50,000 scale, of NTS map sheets 2D/11, 2D/12, 2D/14 and 2D/15 (Figure 1). Striation mapping is an effective method of obtaining a broad understanding of the general ice-flow history, over a wide, regional area.

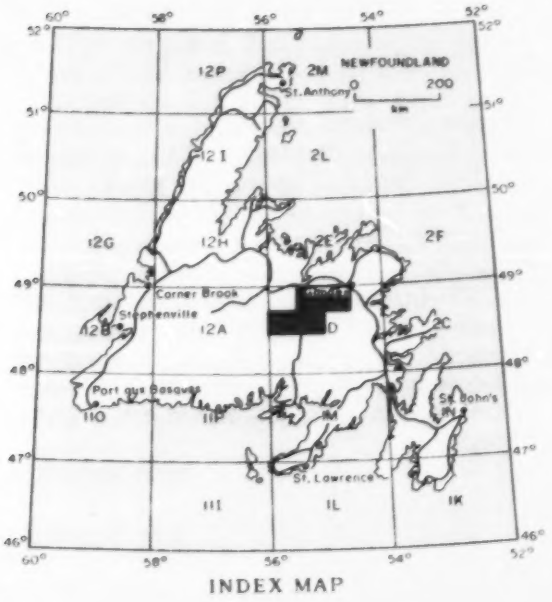

Figure 1. Index Map

RESULTS

Approximately 325 single and multiple striation sites were observed and recorded during the field season. Ice-flow direction can be determined from the morphology of the bedrock surface using such features as stoss and lee, nailheads and chattermarks. Sites that indicate more than a single ice-flow direction suggest either multiple separate flow events or possibly different ice-flow directions within one flow event. Relative temporal relationships between the flows are indicated by crosscutting characteristics and leeside preservation.

The data collected, suggests the existence for three separate glacial ice-flow events, over all or parts of north-central Newfoundland. Of the three glacial events, the first and the earliest ice-flow direction trends southeastward and was found, mainly west of Gander Lake; the next and second ice-flow direction was eastward and is identified at several sites throughout the region; and, the third and the most recent ice flow identified had a north-northeastward trend and is widespread over the entire region. The absolute age of these ice-flow events is not known.

IMPLICATIONS FOR DRIFT PROSPECTING

An understanding of ice-flow history of this region will aid mineral exploration, when interpreting data derived from mineralized float or geochemical anomalies. In general, the most recent flow is expected to be associated with the occurrence of a geochemical anomaly or dispersal pattern. However, in this case, where multiple flows have been identified, the earlier flows should be considered: 1) the earlier ice flows of east

and southeastward may have initially dispersed the sediment before it was affected by the later north-northeast flow, and 2) most of the area has a thick drift cover and it is possible that a complex till stratigraphy exists over parts of the region. In such cases, provenance and thus geochemistry of each till sheet will differ, and care must be taken in sampling.

SUMMARY

This data from north-central Newfoundland when combined with existing data to the north, (Vanderveer, *unpublished;* Vanderveer and Taylor, 1987), the west (Vanderveer and Sparkes, 1980) and to the south (Proudfoot *et al.*, 1988) will give a corridor of coverage from the Bay of Exploits/Gander Bay to Bay D'Espoir. It is planned to extend this coverage over the coming years.

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GENERAL PROJECTS

AN INVENTORY OF GEOCHEMICAL DATA FILES

James Butler
Geochemistry and Geophysics Section

A large amount of geochemical data is presently filed within the Geological Survey Branch. Included in this list are field and analytical results from the lake sediment, stream, soil and rock sampling programs. Many of these records are presently in some usable form, but considerable work remains to be done, to complete and document the various data sets.

The following is a list of the datasets that are in various stages of being completed. The order of this list is an indication of the completeness of each file.

Stream Sediment Data File - Labrador

This file contains the stream sediment data, both field and analytical information, collected during the NGR (National Geochemical Reconnaissance) Program in northern Labrador(NTS 14M and part of 14L, 24I, 24P and 25A). It occupies about 418K of space and is stored on magnetic tape, as an ASCII file, complete with documentation.

Lake Sediment Data File - Newfoundland

This file is essentially complete for the island of Newfoundland. The file is presently stored as an SPSSX savefile, as one complete file and 17 individual files, based on the 1:250,000 NTS maps for Newfoundland. Each file contains field and analytical data. The file is presently 5.1 mb and requires updating only as new data become available under the ongoing re-analysis program.

Granite Data File - Newfoundland

The granite file, which contains data from samples collected during various projects since 1972, is in an advanced stage of development. It is presently 2.4 mb and is stored on magnetic tape as an SPSSX savefile. Copies of the data grouped by pluton, are also stored on floppy disk as SPSSX export files. Updating is carried out as additional data become available.

Lake Sediment Data File - Labrador

This data file contains all the field and analytical data of the program conducted by the Federal Department of Energy, Mines and Resources. It is presently stored as an SPSSX save file on magnetic tape. It occupies 3.5 mb and is updated as new data become available. Some refinements remain to be done on this file.

Granite Data File - Labrador

This data file is in the early stages of development. Presently two files exist, each of which contain field locations and analytical results for two areas in southeastern Labrador (includes parts of NTS 3C, 3D, 3E, 13A, 13G, 13H, 13I, 13J, 13K and 13O). They are stored on magnetic tape as SPSSX savefiles and are a total of 0.8 mb in size. Data accumulation is ongoing and an additional amount of work is required to create a fully verified and documented file.

Quaternary Data File - Newfoundland

The Quaternary data file for insular Newfoundland exists as a 1.4 mb SPSSX savefile, which contains about 1200 cases and is essentially complete for the areas covered (NTS 11O and 11P). Some cleanup and corrections remain to be done on the file and documentation is limited. The file contains field data, such as site, pebble, textural and geochemical data. Updating will be done as new data become available.

Quaternary Data File - Labrador

The Quaternary data file for Labrador relates to four specific areas of Labrador and include Strange Lake (24A/8, 14D/5), Melody Lake (13J/12, 13K/9), Moran Lake (13K/7, 13K/10) and Letitia Lake (13L/1, 13L/8). The file contains positional and some field data and analytical data. It is approximately 700K and is an SPSSPC savefile. It is essentially complete for these areas. The documentation is partically complete.

A number of smaller geochemical data bases also exists. These files contain the results of detailed work conducted by members of the Geochemistry and Geophysics section both on the island and in Labrador. These files will be compiled over the next year and either incorporated into the existing data bases or new data bases will be created to accommodate them. Current backups are on magnetic tape and 5.25-inch floppy disks. Permanent backup of the various databases will be stored at the Newfoundland and Labrador Computer Services.

These data are available to interested persons/parties on the standard 360K double sided, double density, 5.25-inch floppy disks for IBM and compatibles in an ASCII format. The data can also be made available on high density 1.2 mb 5.25-inch floppy disks; 1.4 mb 3.5-inch floppy disks; and special requests for MacIntosh compatible disks can also be accomodated.

CORE STORAGE PROGRAM, 1989

A. Harris and S. Cochrane
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Mineral Resource Management Branch

INTRODUCTION

In 1979, the Newfoundland Department of Mines started a drill core collection and storage program. The objective of this ongoing program is to provide well maintained and representative collections of drill core from as many drilling programs as possible, for the future use of the mineral exploration industry, government, and university geoscientists and other geotechnical professionals.

This report summarizes activities during 1989 and presents an overview of the operations of the core storage program.

DRILL CORE ACQUISITION

During 1989, drill core acquisition continued in insular Newfoundland and 8,000 m of drill core samples were added to the collection. Most of these core samples, 6,233 m, were delivered to our core libraries by exploration companies for confidential storage and 1,767 m were collected by project personnel.

In Labrador, all core samples (1,808 m) from the Kennco Explorations Ltd. 1959 drilling program in the Seal Lake area, were collected from the Whisky Lake camp and have been prepared for shipment to Goose Bay in 1990. In total, approximately 675,783 m of drill core samples are now being stored.

A catalogue of all open core samples in Department core libraries is available from the Publications and Information Section of the Department of Mines and Energy.

DRILL CORE LIBRARIES

The Department of Mines and Energy now operates six core libraries located at St. John's, Buchans, Springdale, Baie Verte, Pasadena and Goose Bay.

The St. John's library is staffed on a full-time basis except during the field season. It is equipped with a rock saw, a stereomicroscope, a magnetic susceptibility meter, a resistivity meter, an ultraviolet light and a McPhar TV-1 scintillometer.

The Goose Bay core library, which contains core from Labrador, is not staffed on a full-time basis. It has facilities similar to and shares equipment with, the St. John's core library.

The Pasadena core library is also staffed on a full-time basis. This library has equipment similar to the St. John's library along with a ventilated room for storing radioactive core and a humidity-controlled room for storing salt core. The Pasadena building is filled to capacity with only a little working space made free for new core additions by moving some "low priority" core outside the building for continued storage.

The Springdale library is operated by the resident Pasadena geologist from the Pasadena core library, on an appointment basis only. It has a core splitter and a rock saw but shares other geotechnical instruments with the Pasadena core library. The extension to the core storage racks in the Springdale building during late fall 1989 will permit storage of additional core samples in the facility this year.

The Buchans core library contains core samples from drilling done by ASARCO and Abitibi-Price during the years these companies were active in mining and mineral exploration in Buchans and surrounding areas. This core library is not as yet fully operational because it does not contain an office/core examination area and does not have staff assigned to it. Drillhole logs, location maps and other data on core in the Buchans library are being stored in Pasadena and all visits to the Buchans core library are being handled by

staff from the Pasadena core library, on an appointment basis. Tenders will be called, in the fall of 1989, for construction of an office and laboratory complex in the Buchans core storage library and this facility will be fully operational by spring 1990.

A core storage building has been acquired in Baie Verte. Construction of core storage racks and renovations to the office area in this building will begin this fall and this facility will be operational as soon as construction is completed. This core library will also be operated from Pasadena.

INFORMATION FILES

The St. John's office and the Pasadena core library now have microcomputers to assist in searching our core sample holdings and to search data files kept on core samples in our core libraries.

Two data files are currently available for searches in Pasadena and St. John's. One file contains the drillhole index data, parts of which are used to compile the drillhole catalog and the other file contains a summary of all assays conducted on core samples stored in our core libraries, excluding Buchans.

PLANS

During late 1989 or early 1990, the core storage libraries at Buchans and Baie Verte will be made operational. Despite ongoing space problems in the Pasadena and Springdale core libraries, storage of confidential core in these buildings is being permitted and the drillhole index data and assay data files will be made available on floppy disks by the end of this year.

MINERAL OCCURRENCE DATA SYSTEM

C.F. O'Driscoll, J. Smith, G. Stapleton and D. King
Mineral Deposits Section

The Mineral Occurrence Data System (MODS) provides information on the known mineral occurrences in Newfoundland and Labrador. It consists of a manual Mineral Inventory File and a computerized Mineral Index.

The Mineral Inventory File consists of mineral occurrence descriptions that summarize all data on known mineral occurrences in the province. The file presently contains approximately 4000 descriptions, including all mineral occurrences for insular Newfoundland (Figure 1), and selected areas in Labrador (Figure 2). The file and topographic location maps have been microfiched and duplicates are available upon request.

The Mineral Inventory File is presently being updated with new mineral occurrence descriptions. Map areas that have been updated include major parts of 12A, 12B and 12H. In addition, industrial minerals for all of Newfoundland have been documented.

Mineral occurrence maps that have updated geological bases have been published at a 1:250,000 scale and are available upon request. In addition, selected areas have been published at 1:50,000 and 1:10,000 scales. These maps contain locations, a listing and a brief description of the occurrences.

The computerized Mineral Index contains information extracted from the Mineral Inventory File, which is stored on a Hewlett Packard 9000/560 Unix-operated mini-computer. The database presently contains information on approximately 3700 mineral occurrences. Work is in progress to make it more accessible.

An index to all the province's industrial mineral occurrences is also available. This database utilizes IBM compatible REFLEX software stored on a H.P. Vectra ES/12 microcomputer. Users interested in a particular commodity can retrieve a listing of that commodity's occurrences, thus simplifying their search of the manual file.

The manual Mineral Inventory File is used as a quick reference for specific deposits. It is used daily by exploration company personnel and by government geoscientists. The file is available to anyone who is researching mineral deposits in the province.

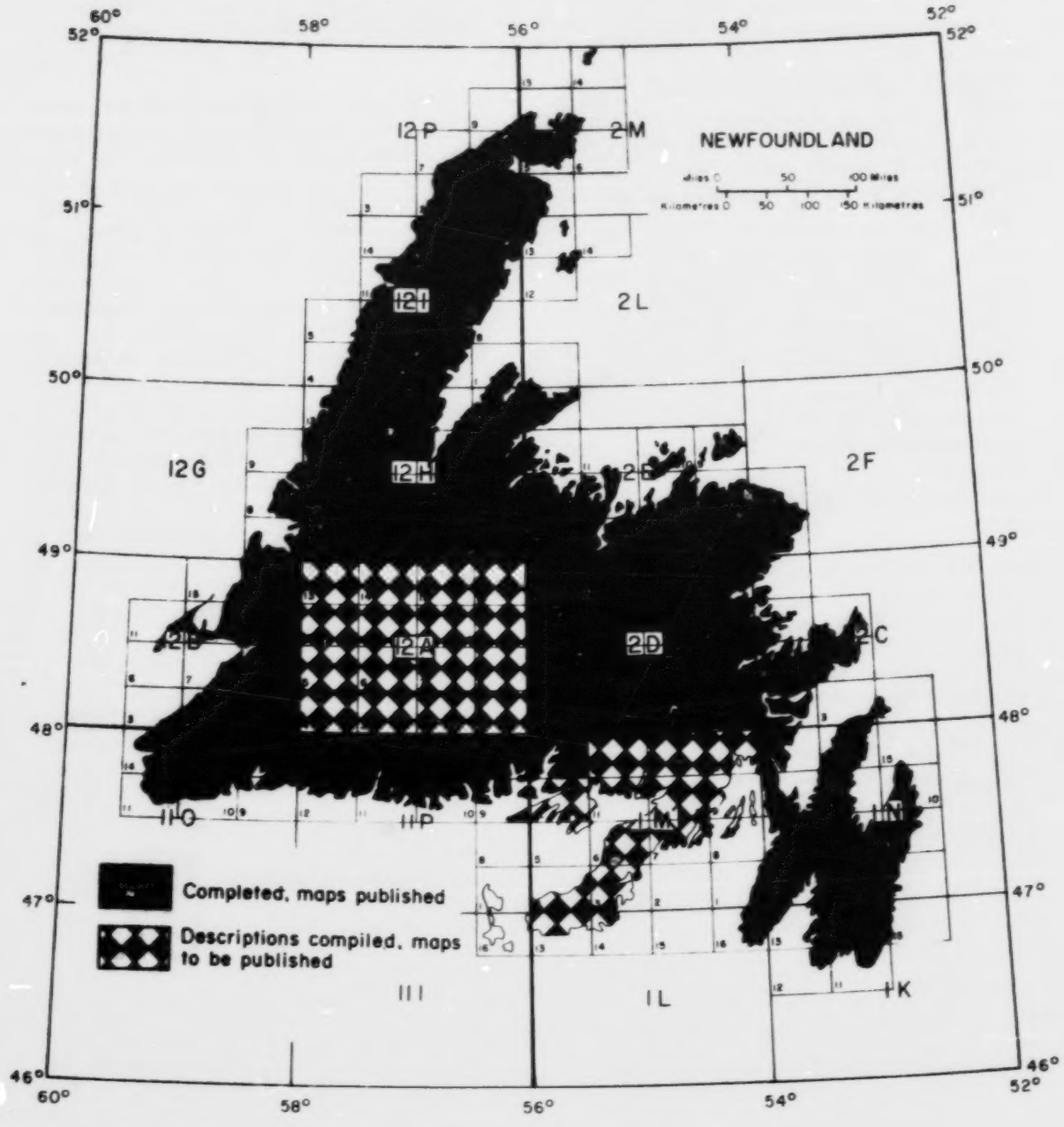

Figure 1. Index map for Mineral Occurrence Data System project, insular Newfoundland.

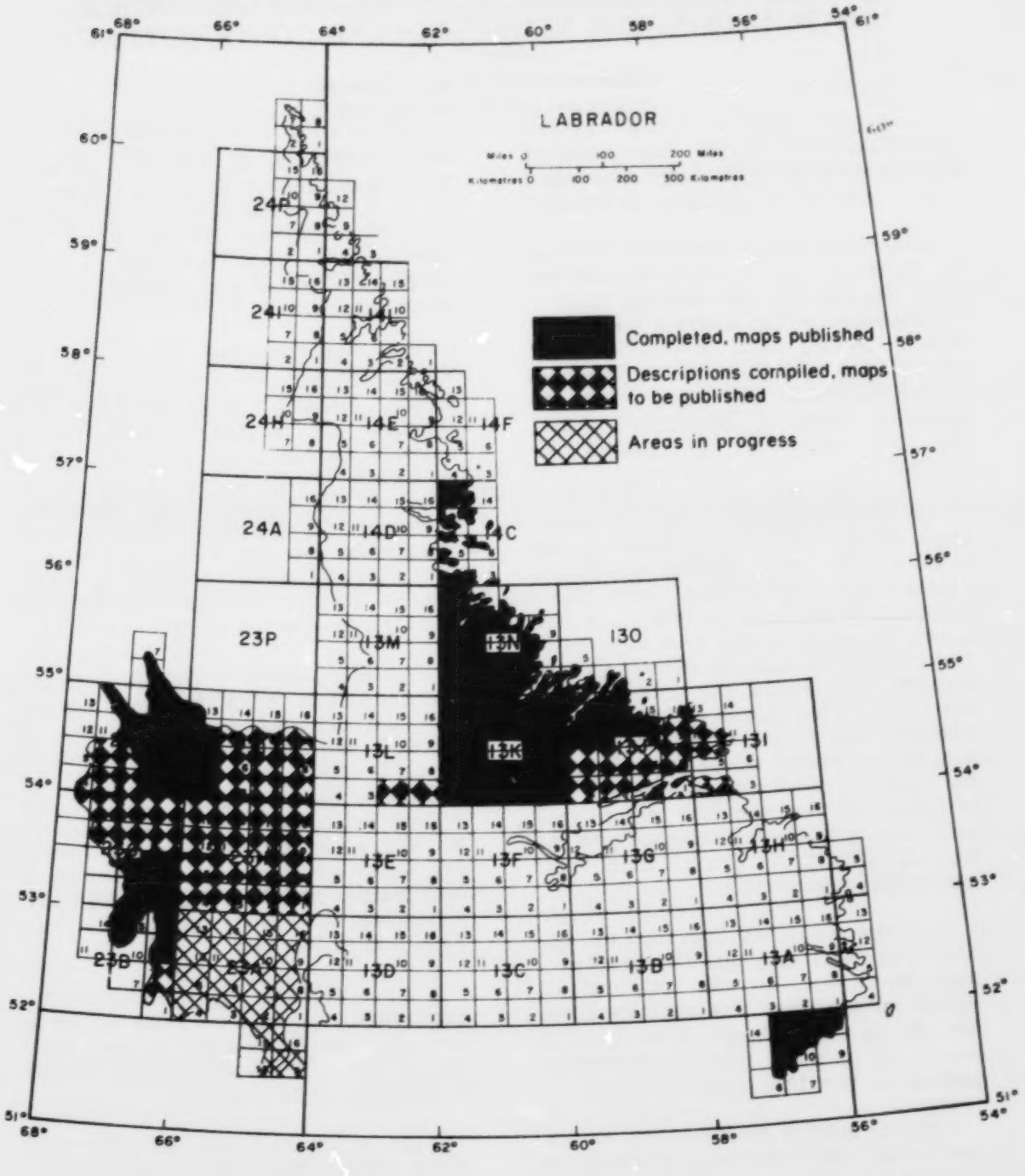

Figure 2. Index map for Mineral Occurrence Data System project, Labrador.

GEOSCAN - THE NATIONAL DATABASE FOR GEOLOGICAL INFORMATION: THE NEWFOUNDLAND CONTRIBUTION

Catherine Patey and Janet Gillespie
Publications and Information Section

GEOSCAN is a computerized bibliographic database of Canadian produced and/or Canada-related geoscience documents.

The Newfoundland Department of Mines and Energy is one of sixteen agencies that index documents for input into this database. The departmental files, including geoscientific mineral inventory cards, assessment reports, published reports and maps are the sources of the indexed records. Other agencies, e.g., the Geological Survey of Canada, also produce and index documents that concern this province.

In 1982, the National GEOSCAN Centre, which manages GEOSCAN, installed a new software system, called MINISIS, to input and retrieve the bibliographic data more effectively. In the implementation of the new system, all the old records were converted to a new format. For example, different types of keywords were moved into different fields: map types, illustrations, geological terms. Although most of the records did convert, they did not convert cleanly and completely. For example, records may be missing a title or authors and terms may have been assigned to the wrong fields. In cooperation with the National GEOSCAN Centre, these older records are being corrected.

All new records are input onto the new system via batch entry and are immediately retrievable, online. To date, only indexed records for assessment files are being keyed into the system, although other types of records, in particular, those for government publications, have been coded.

Besides indexing and keying new records, new coding sheets are being produced; the authority files and thesauri used in coding are being enlarged, and the terms used are being more clearly defined to maintain consistent use of terms. Various card files, e.g., mineral lands information card file, were begun. The information on these card files is being transferred to several mini databases for easy access and reference.

The non-confidential records in the 107,068 GEOSCAN records from across Canada, including those concerning this province, are available through online computer searches at the Geological Survey of Canada Library in Ottawa and in St. John's, at the Publications and Information Section of the Geological Survey Branch. Searches are done on a cost-recovery basis with a minimal charge of $10.00 per search topic. A moderate size search (100 to 200 titles) cost between $15 and $45.

As well, GEOSCAN Newfoundland and Labrador indices, (NTS, keywords, authors, both corporate and personal), current to February 1982, the date of the last update on the old system, are available from the Publications and Information Section. Also available are computer printout indices sorted by NTS values, to assessment files entered into GEOSCAN from 1982 to 1984, and a NTS index to assessment files received in the Publications and Information geofiles from April 1985 to June 1988.

We welcome suggestions for improvements and appreciate being notified of any errors or discrepancies in the earlier indices. This will aid us in making detailed modifications of the documents.

For further information on GEOSCAN, please contact Catherine Patey (709)576-6441.

REPORT OF THE GEOCHEMICAL LABORATORY FOR 1989

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Geochemistry and Geophysics Section

The number of determinations performed by the Geochemical Laboratory from September 1, 1988 to August 31, 1989 is summarized in Table 1. The total is 39 percent less than in the same period last year, due to a decreased demand at the end of the current Canada - Newfoundland Mineral Development Agreement.

There has also been a substantial decrease in samples prepared and sent for outside analysis to commercial laboratories - mainly for gold and associated elements by multi-element neutron activation analysis. The analytical work on the samples submitted during the 1988 field season has been completed.

Work continues, to expand the number of element analyses by ICP from 20 to 48. Computer systems and software are being developed to handle requests for analytical work and to monitor the progress of each geologist's requirement through to completion, and also to computerize analytical data storage and reporting.

Table 1. Summary of output from the Geochemical Laboratory for the period September 1, 1988 to August 31, 1989.

Geochemical analysis of soil, till, lake and stream sediments	1869
Silicate analysis	
Major-elements A.A.	10083
ICP	2545
Classical	3488
Potentiometric	1683
Trace-elements A.A.	17105
ICP	55123
Miscellaneous analysis, assays, H_2O-, H_2O+, CO_2, S	423
Total	92319

Sample Preparation

Rock samples crushed	1342
Rock samples pulverized	2013
Lake, stream and soil samples sieved	115
Samples split, samples shipped for outside analysis, samples recombined	1825
Samples weighed for outside analysis	2483